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ASSESSMENT OF DAMAGE TOLERANCE REQUIREMENTS AND ANALYSES:
A user's manual for crack growth and crack initiation analysis: "DAMGRO"

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A structural test program of typical aircraft structural configurations was conducted to assess the current Air Force damage tolerance design requirements defined in MIL-A-83444. The specimens, made of 2024-T3XX and 7075-T6XX, were subjected to randomized flight-by-flight spectra, representative of fighter/trainer and bomber/cargo type loading spectra, respectively, and to a constant amplitude loading spectrum. A total of two-hundred fifty-six specimens were tested. The test results were correlated with analytical predictions using crack growth and crack initiation methods. As a result of this study, recommendation is provided to the validity of MIL-A-83444, to develop guidelines for selection of critical crack locations, and to assess the state-of-the-art analytical capabilities in predicting crack growth and crack initiation time.

This report presents the user's manual of the computer program "DAMGRO". This program has been developed in conjunction with this contract, and used to predict the crack growth and crack initiation of the structural test specimens.

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FOREWORD

This report presents the User's Manual for Crack Growth and Crack Initiation Computer Program "DAMGRO" developed as part of the "Assessment of Damage Tolerance Requirements and Analyses", contract No. F33615-82-C-3215. This program has been administrated by the Flight Dynamics Laboratory, Air Force Wright Aeronautical Laboratories, Air Force Systems Command, Wright Patterson Air Force Base, Ohio. James L. Rudd (AFWAL/FIBEC) was the Air Force Project Engineer through December 1985. Subsequently, Mr Rudd was replaced by Lt Christopher Mazur. A. Kuo was the Program Manager and Principal Investigator through March 1985. Subsequently, Mr Kuo was replaced by Meir Levy for the completion of the program. The structural test program has been performed at the University of Dayton Research Lab under the supervision of George Roth.

The eight major tasks listed below have been planned to achieve the program objectives. Namely, (a) assessing the validity of, and recommending improvements to the current MIL-A-83444, (b) developing guidelines for identifying the most critical initial primary damage locations for typical aircraft structures, and (c) assessing and improving the state-of-the-art analytical methods to satisfy the requirements of MIL-A-83444.

Task I:	Analytical Methods
Task II:	Basic Tests
Task III:	Analytical Predictions
Task IV:	Structural Tests
Task V:	Analytical/Experimental Correlations
Task VI:	Assessment of and Recommended Improvements to MIL-A-83444
Task VII:	Guidelines for Selecting Most Critical Inital Primary Damage Location
Task VIII:	Assessment of and Improvements to Damage Tolerance Analyses

The material presented in this report was developed during Phase I of the contract. Additional five reports were issued including:

Volume I:	Executive Summary
Volume II:	Analytical Methods
Volume III:	Analytical Predictions and Correlations
Volume IV:	Raw Test Data
Volume V:	Assessment and Recommendations

Volume I report contains an Executive Summary of the entire program including the Basic Test Program for material allowables, test results of the Structural Test Program and Analytical Predictions. It also contains a summary of the Analytical Formulation derived during Task I.

Volume II report contains the Analytical Methodology derived during Task I of the Program, including crack growth and crack initiation techniques, and results of Finite Element Modeling of stress intensity factors.

Volume III report contains Analytical to Experimental Correlation of seventy-two (72) Structural Test Specimens performed during Task IV of the Program.

Volume IV report contains the Raw Test Data obtained during the Basic Test, and the Structural Test Programs.

Volume V report contains an assessment of the Damage Tolerance Design Requirements defined in MIL-A-83444, Analytical methods evaluation and a Guideline for Identifying Critical Locations for Damage Tolerance Analysis. It also contains recommendations and follow-on work.

This program began in September 1982 and was completed in May 1986.

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1.0 INTRODUCTION

This report presents a description of the crack growth and crack initiation computer program "DAMGRO". The computer program has the capabilities of simultaneously analyzing crack growth and crack initiation. The three options available are:

(i) Crack Growth Only "Method 1"
(ii) Crack Growth and Crack Initiation "Method 2"
(iii) Crack Initiation Only.

The program is coded in Fortran Computer Language and consists of a total of 22 routines. Various geometrical configurations can be analyzed including plate or stringer sections, subjected to a constant amplitude loading or a randomized spectrum loading. The generalized Willenborg Retardation Model was adopted to be used when a variable amplitude loading spectrum was applied. The crack growth rates 'da/dN' are presented in terms of the modified Walker's equation.

A majority of typical aircraft structural configurations may be accurately modeled using one or more of the available routines. However, some important configurations are not presently available with a prediction accuracy deemed necessary. In particular, growth of two cracks at adjacent holes consistent with the MIL-A-83444 specification. In this case the growth of the primary crack may influence the growth of the secondary one. In performing the prediction, such a configuration was treated independently which may have resulted in unconservative predictions.

In performing crack growth or crack initiation predictions, some structural geometrics are not, explicitly, included in the program. However, modeling techniques may be applied to use available routines to obtain reasonable representations. For example for subroutine K1020, if the two adjacent holes were eliminated, the result will be a crack at the edge of a hole approaching a free edge. Similarly, initiation may be applied to one location when only one hole is present.

The program is constructed in such a way, that additional stress intensity routines may be added. A flow chart of the program is presented in Appendix A. Three examples are presented in Section 3.0.

2.0 DAMGRO COMPUTER PROGRAM

"DAMGRO" Computer Program was developed to have the capability of simultaneously analyzing crack growth and crack initiation at the edge of a hole. Various geometrical configurations may be analyzed using one or more of the routines shown in Figures 2.1-1 through 2.1-10. The program contains ten crack growth and six crack initiation routines. The crack growth is governed by the stress intensity factor at the edge of the crack. The crack initiation is governed by the stress severity factor, which itself is a function of strain energy density at the edge of a hole. The analytical formulation for both crack growth and crack initiation are presented in Volume II of the report.

2.1 CRACK GROWTH "METHOD 1"

Various geometrical configurations may be analyzed using the 'DAMGRO' computer program "Method 1" of the program includes the following configurations:

1. Corner crack emanating from a circular hole, and approaching an adjacent hole (subroutine K1010 Ref. Figure 2.1-1).
2. Corner crack emanating from a circular hole with an additional crack through the thickness extending from the hole to the edge of the part (subroutine K1020 Ref. Figure 2.1-2).
3. Corner crack emanating from a circular hole with an additional crack, through the thickness extending from the hole to the edge of an adjacent hole (subroutine K1030 Ref. Figure 2.1-3).
4. Two equal or unequal size corner cracks at the edge of a circular hole and approaching adjacent holes (subroutine K1040 Ref. Figure 2.1-4).

5. Two equal or unequal size corner cracks at the opposite edges of two adjacent holes, with an additional crack through the thickness extended between the two holes (subroutine K1050 Ref. Figure 2.1-5).
6. Corner crack emanating from a circular hole of a stringer section horizontal leg. The crack may approach the free edge or the stringer upstanding leg, (subroutine K2010 Ref. Figure 2.1-6).
7. Corner crack emanating from a circular hole of a stringer section. An additional crack extending from the hole to the free edge, (subroutine K2020 Ref. Figure 2.1-7).
8. Two corner cracks emanating from a circular hole of a stringer horizontal leg. One crack approaches the stringer upstanding leg, and the second one approaching the free edge of the horizontal leg, (subroutine K2040 Ref. Figure 2.1-8).
9. A crack emanating from a circular hole of a stringer tee section, and propagating into the upstanding leg, (subroutine K2050 Ref. Figure 2.1-9).
10. A crack emanating from a circular hole of a stringer 'L' section, and propagating into the upstanding leg, (subroutine K2060 Ref. Figure 2.1-10).

2.2 COMBINED CRACK GROWTH AND CRACK INITIATION "METHOD 2"

The combined method routines (Method 2) are capable of predicting crack initiation for the following geometrical configurations:

1. Crack initiation at the edge of two adjacent holes with one crack present at one of the holes, (subroutines S1010 and S1020 Ref. Figures 2.2-1 and 2.2-2).

2. Crack initiation at the edge of two holes in an array of three holes with two cracks present at the mid hole, (subroutine S1030 Ref. Figure 2.2-3).

3. Crack initiation at the edge of two adjacent holes with a through the thickness crack between them, (subroutine S1040 Ref. Figure 2.2-4).

4. Crack initiation at the edge of two holes in an array of three holes with the presence of one crack at the edge of one hole and a second through the thickness crack between two holes, (subroutine S1050 Ref. Figure 2.2-5).

5. Crack initiation at the edge of two adjacent holes with a crack extending from one hole to the edge of the part, (subroutine S1060 Ref. Figure 2.2-6).

2.2.1 Input Data Description of "Method 2"

The input parameters needed to perform the crack initiation (0.050 inch corner crack) are defined in Volume II of the report and summarized below:

(i) Damage index 'di' for the initiation of a 0.050 inch quarter-circular corner crack was derived during Phase I of the program. The index for 2024-T3 and 7075-T651 is given by the following equation:

(i) For Group A (no interference, clamp-up or sealant)

$di = 1.0 - 0.629\, S_{max}$ for 2024-T3

$di = 0.873 - 0.795\, S_{max}$ for 7075-T651

(ii) For Group B, C and D (with interference, clamp-up or sealant)

$di = 1.0 - 0.580\, S_{max}$ for 2024-T3

$di = 0.958 - 0.619\, S_{max}$ for 7075-T651

where $S_{max} = 0.5\ (\sigma K)^2/E$, $K = 1 + (K_t - 1)/(1 + \sqrt{\rho/R})$. The equations above represent the damage index for crack initiation of specimens subjected to a constant amplitude loading spectrum. For specimens subjected to a randomized loading spectrum, the damage index 'D_f' to initiate a 0.05 inch quarter-circular corner crack, was determined using weighted average.

(ii) Crack Initiation Constants

1. Strain energy density $S = S_F(N)^m$

$S = 10.4261\ N^{-0.366}$ for 2024-T3

$S = 20.4257\ N^{-0.4515}$ for 7075-T651

where N is the number of cycles to failure.

(iii) Geometry parameters α, β, γ

(i) Group A

$\alpha\beta\gamma = 1.0$

(ii) Group B

$\alpha\beta\gamma = 0.8503$ for 2024-T3

$= 0.8126$ for 7075-T651

(iv) Other parameters which were found to improve fatigue initiation life are:

(i) Stress due to faying surface, FAYSUR.

(ii) Stress level due to Hi-Lok clamp-up, FRICT.

As a conservative assumption, the faying surface stress and the Hi-Lok clamp-up stress may be set to zero.

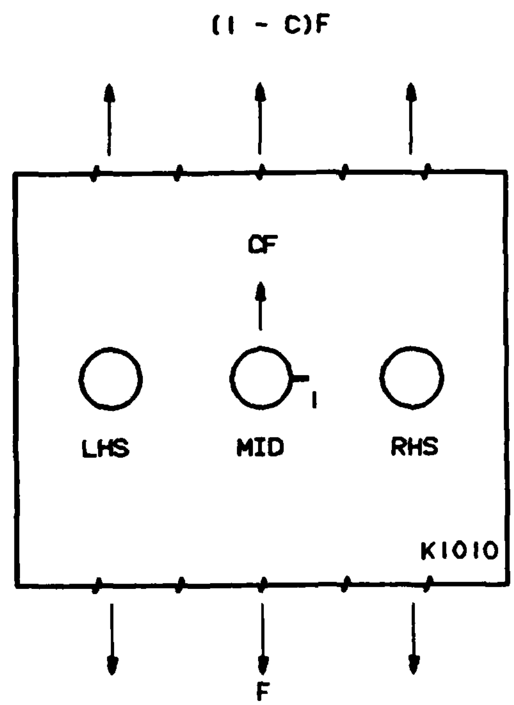


Figure 2.1-1. Geometrical Configuration of Crack Growth Routine K1010

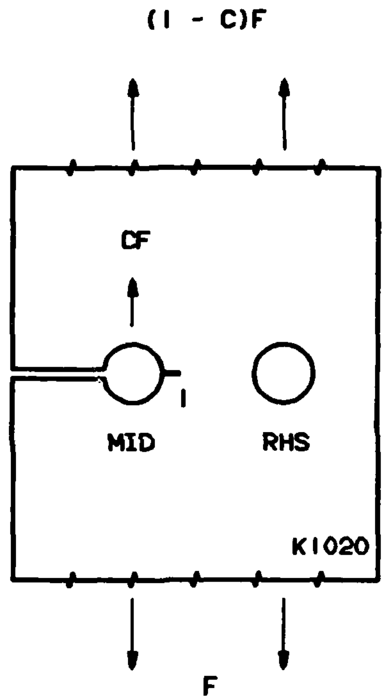


Figure 2.1-2. Geometrical Configuration of Crack Growth Routine K1020

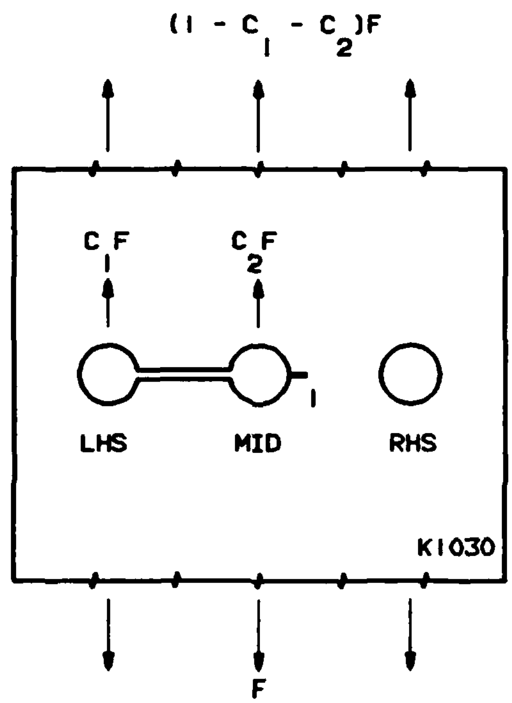


Figure 2.1-3. Geometrical Configuration of Crack Growth Routine K1030

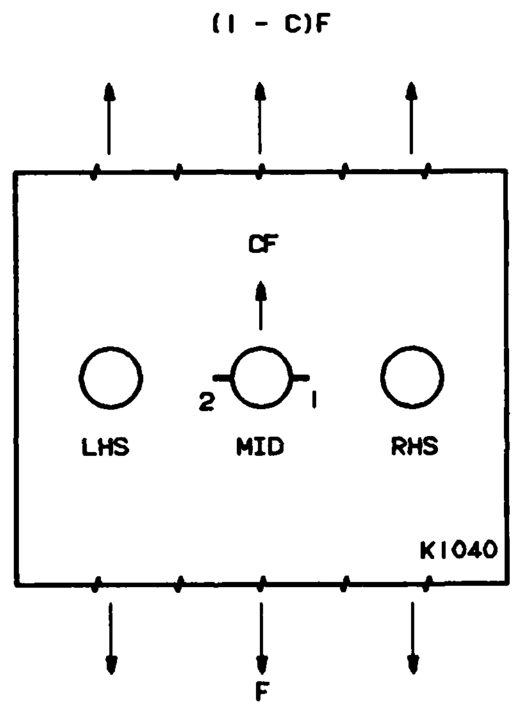


Figure 2.1-4. Geometrical Configuration of Crack Growth Routine K1040

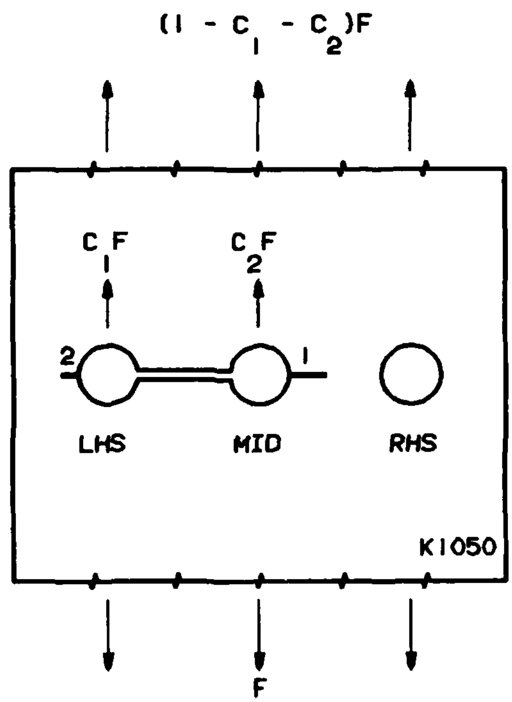


Figure 2.1-5. Geometrical Configuration of Crack Growth Routine K1050

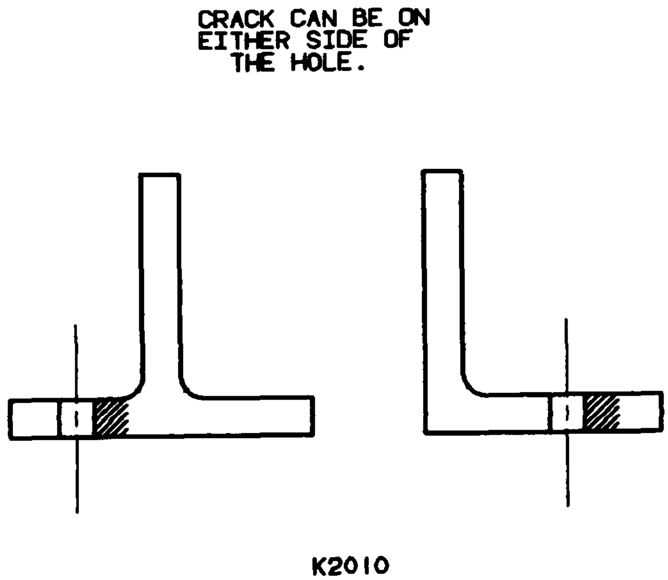


Figure 2.1-6. Geometrical Configuration of Crack Growth Routine K2010

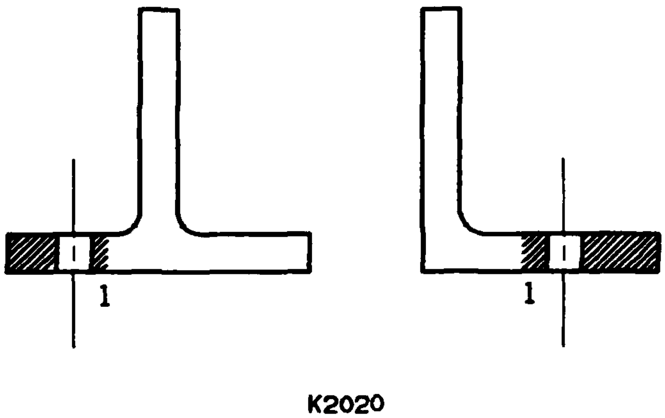
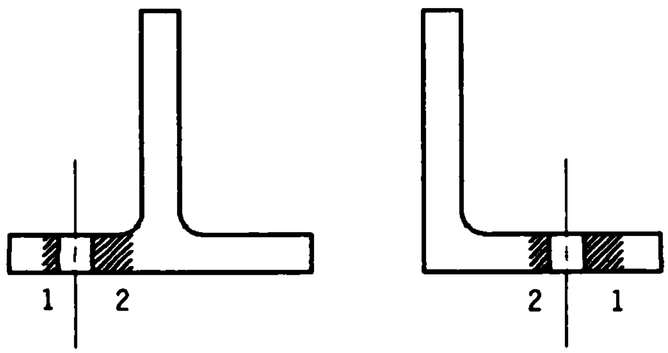


Figure 2.1-7. Geometrical Configuration of Crack Growth Routine K2020



K2040

Figure 2.1-8. Geometrical Configuration of Crack Growth Routine K2040

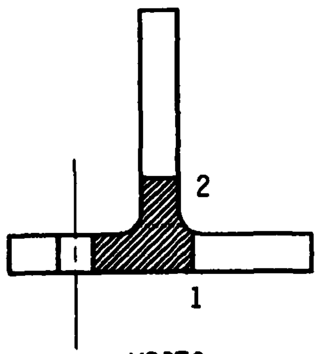


Figure 2.1-9. Geometrical Configuration of Crack Growth Routine K2050

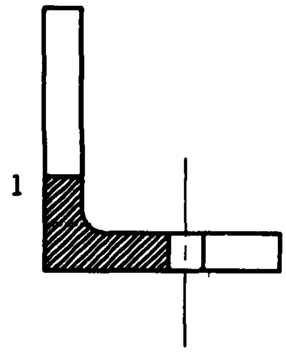


Figure 2.1-10. Geometrical Configuration of Crack Growth Routine K2060

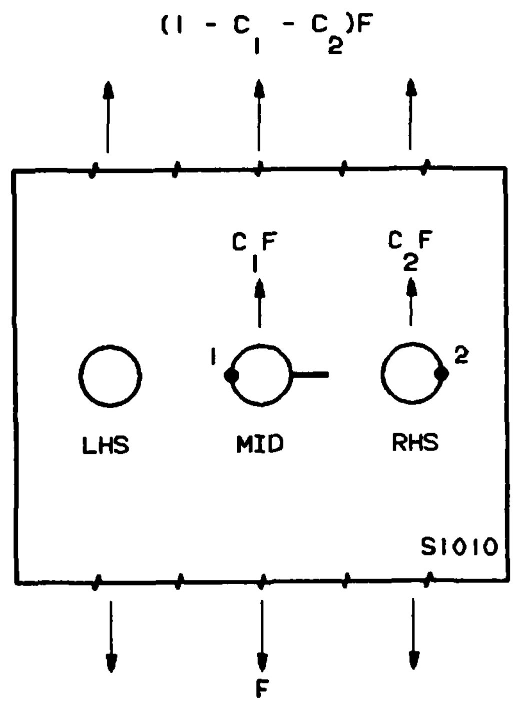


Figure 2.2-1. Geometrical Configuration of Crack Initiation Routine S1010

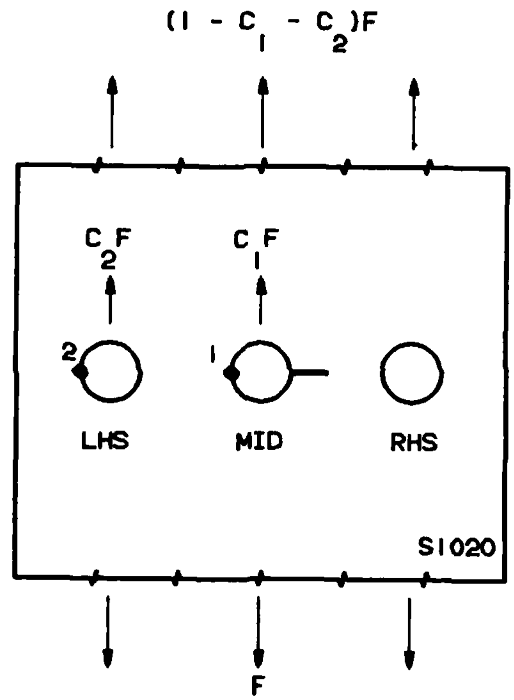


Figure 2.2-2. Geometrical Configuration of Crack Initiation Routine S1020

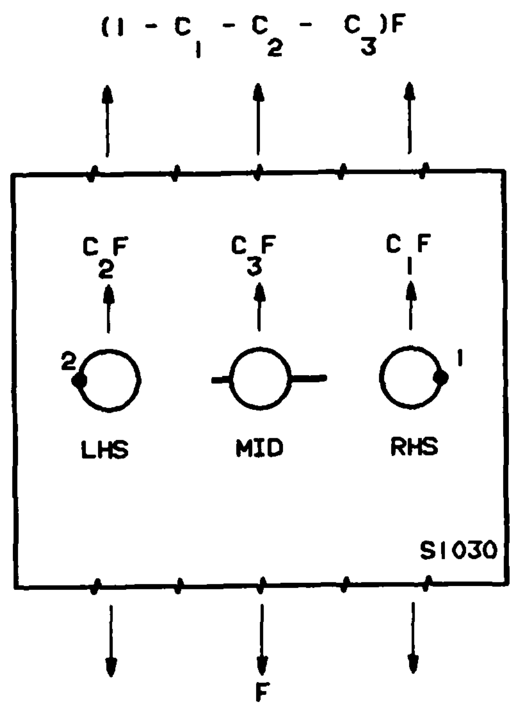


Figure 2.2-3. Geometrical Configuration of Crack Initiation Routine S1030

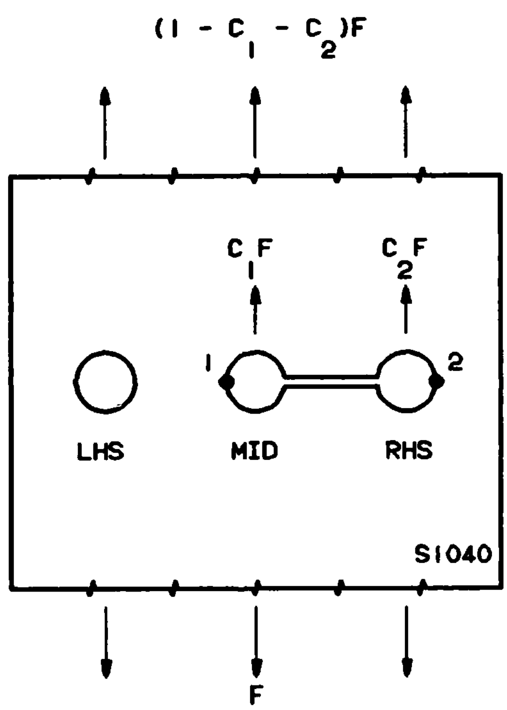


Figure 2.2-4. Geometrical Configuration of Crack Initiation Routine S1040

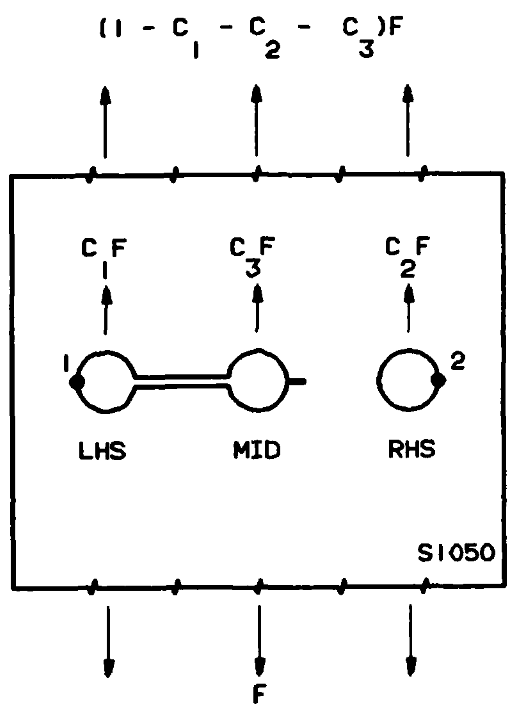


Figure 2.2-5. Geometrical Configuration of Crack Initiation Routine S1050

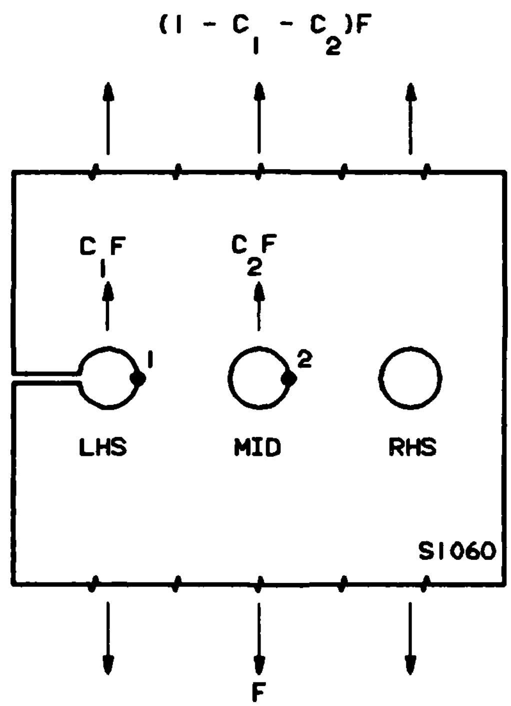


Figure 2.2-6. Geometrical Configuration of Crack Initiation Routine S1060

2.3 DAMGRO INPUT FORMAT

The following pages describe the input format for the DAMGRO Computer Program. Two files are needed to run the program. "File 1" contains geometrical configurations and material allowables (Ref. Table 2.3-1 and pages 25 through 39) and "File 2" contains the spectrum loading considered (Ref. page 40)

TABLE 2.3-1. 'DAMGRO' INPUT FILE FORMAT

INPUT									FORMAT
TITLE									(20A4)
RMATID									(20A4)
WALKC	WALKM	WALKN	WALKMC	WALKMM	WALKMN				(6E10.3)
CKC	AKIC	SIGMAY	CKMXTH	SHUTOF	RCUT	RCUTN			(7F10.4)
SF	RM	DMG	ELAMOD	ZOU	ALPHA	BETA	GAMMA		(8F10.4)
CI1	CF1	AI1	AF1	CI2	CF2	AI2	AF2		(8F10.5)
APAOL1	APCOL1	RYAOL1	RYCOL1	AKOL1	CKOL1	AOL1	COL1		(8E10.4)
APAOL2	APCOL2	RYAOL2	RYCOL2	AKOL2	CKOL2	AOL2	COL2		(8E10.4)
DMG1	DMGOL1	DELOG1	DMG2	DMGOL2	DELOG2				(6E10.4)
THK	RADIUS	B1	B2	BOLTM1	BOLTM2	EOD	CSK	PINDEF	(7F10.4, F5.1, F5.2)
RAD1	RAD2	HODIS1	HODIS2	BOLTR1	BOLTR2	BOLTL1	BOLTL2		(8F10.4)
FRICT	FAYSUR								(2F10.4)
IRESTA	NSOLD	NCRKS	NINITS	IRETAD	NBLKS	KID	LID		(8I5)
VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7	VAR8		(8F10.4)
FLTBLK	BLKLIF	FLTHR	ISTRESS						(3F10.4, I10)

FILE 1: INPUT DATA CARD NO. 1

DESCRIPTION: TITLE

FORMAT: 20A4

FIELD	1 - 80
VARIABLE	TITLE (I)
EXAMPLE	SPECIMEN NO. ABC-1 SUBJECTED TO A-10A LOADING SPECTRUM

VARIABLE	DESCRIPTION
TITLE (I) I = 1, 20	Any alphanumeric data for problem information, fields 1 through 80.

REMARKS (1) One title card printed on the first page of the output file.

FILE 1: INPUT DATA CARD NO. 2

DESCRIPTION: MATERIAL OR ID INFORMATION

FORMAT: 20A4

FIELD	1 - 80
VARIABLE	RMATID (I)
EXAMPLE	2024-T351 EXT. (REF. DAMAGE TOLERANCE HANDBOOK)

VARIABLE	DESCRIPTION
RMATID (I) I = 1, 20	Any alphanumeric data for material information, fields 1 through 80.

REMARKS (1) One title card printed on the first page of the output file. Non executable data.

FILE 1: INPUT DATA CARD NO. 3

DESCRIPTION: CRACK GROWTH RATE CONSTANTS

FORMAT: 6E10.3

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	
VARIABLE	WALKC	WALKM	WALKN	WALKMC	WALKMM	WALKMN	
EXAMPLE	0.160E-09	0.650	4.554	0.230E-08	1.00	3.115	

<u>VARIABLE</u>	<u>DESCRIPTION</u>
WALKC	'C' coefficient in Walker's equation for $R \geq 0$
WALKM	'm' coefficient in Walker's equation for $R \geq 0$
WALKMC	'n' coefficient in Walker's equation for $R \geq 0$
WALKMC	'C' coefficient in Walker's equation for $R < 0$
WALKMM	'm' coefficient in Walker's equation for $R < 0$
WALKMN	'n' coefficient in Walker's equation for $R < 0$

<u>REMARKS</u> (1) To represent the modified Walker's equation:

$$\frac{da}{dN} = C\left(\left(1-R\right)^m K_{max}\right)^n$$

FILE 1: INPUT DATA CARD NO. 4

DESCRIPTION: MATERIAL PROPERTIES FOR CRACK GROWTH

FORMAT: 7F10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	
VARIABLE	CKC	K_{IC}	SIGMAY	CKMXTH	SHUTOF	RCUT	RCUTN	
EXAMPLE	58.0	36.0	53.30	2.0	2.3	0.99	-0.99	

VARIABLE	DESCRIPTION
CKC	Plane stress fracture toughness, K_c
KIC	Plane strain fracture toughness, K_{Ic}
SIGMAY	Tensile yield stress, F_{ty}
CKMXTH	K_{max} for threshold da/dn
SHUTOF	Retardation shut-off ratio
RCUT	Postive stress ratio 'R' cut-off
RCUTN	Negative stress ratio 'R' cut-off

REMARKS (1) Executable data when Method 1 is used.

FILE 1: INPUT DATA CARD NO. 5

DESCRIPTION: MATERIAL PROPERTIES FOR CRACK INITIATION

FORMAT: 8F10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
VARIABLE	SF	RM	DMG	ELAMOD	ZOU	ALPHA	BETA	GAMMA
EXAMPLE	10.426	-0.366	0.872	0.107E5	0.022	0.875	1.0	1.0

VARIABLE	DESCRIPTION
SF	Crack initiation eqn. constant, SF
RM	Crack initiation eqn. constant, m
DMG	Damage index for crack initiation, d_i
ELAMOD	Elastic modulus, E
ZOU	Nueber material constant, ρ
ALPHA	Stress severity factor parameter, α
BETA	Stress severity factor parameter, β
GAMMA	Stress severity factor parameter, γ

REMARKS (1) Executable when Method 2 is used.

FILE 1: INPUT DATA CARD NO. 6

DESCRIPTION: CRACK SIZE DATA

FORMAT: 8F10.5

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
VARIABLE	CTI	CFI	AI1	AF1	CI2	CF2	CI2	CF2
EXAMPLE	0.050	0.75	0.050	0.188	0.0	0.0	0.0	0.0

<u>VARIABLE</u>	<u>DESCRIPTION</u>
CI1	Initial crack length of crack No. 1
CF1	Final crack length of crack No. 1
AI1	Initial crack depth of crack No. 1
AF1	Final crack depth of crack No. 1
CI2	Initial crack length of crack No. 2
CF2	Final crack length of crack No. 2
CI2	Initial crack depth of crack No. 2
CF2	Final crack depth of crack No. 2

<u>REMARKS</u> (1) Initial flaw configuration consistent with the subroutines for growth and initiation.

FILE 1: INPUT DATA CARD NO. 7

DESCRIPTION: RETARDATION PARAMETERS AT THE EDGE OF CRACK NO. 1

FORMAT: 8E10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
VARIABLE	APAOL1	APCOL1	RYAOL1	RYCOL1	AKOL1	CKOL1	AOL1	COL1
EXAMPLE	0.192E0	.889E0	.386E-2	.241E-1	.144E2	.208E2	.188E0	.865E0

VARIABLE	DESCRIPTION
APAOL1	Depth of crack No. 1 plus plastic zone size at overload
APCOL1	Length of crack No. 1 plus plastic zone size at overload
RYAOL1	Plane strain plastic zone for crack No. 1 at overload
RYCOL1	Plane stress plastic zone for crack No. 1 at overload
AKOL1	Depth direction K_{max} for crack No. 1 at overload
CKOL1	Surface direction K_{max} for crack No. 1 at overload
AOL1	Depth of crack No. 1 at overload
COL1	Length of crack No. 1 at overload

REMARKS (1) Executable when Method 1 is used.

(2) Initial values are equal to 0.0.

FILE 1: INPUT DATA CARD NO. 8

DESCRIPTION: RETARDATION PARAMETERS AT THE EDGE OF CRACK NO. 2

FORMAT: 8E10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
VARIABLE	APAOL2	APCOL2	RYAOL2	RYCOL2	AKOL2	CKOL2	AOL2	COL2
EXAMPLE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

VARIABLE	DESCRIPTION
APAOL2	Depth of crack No. 2 plus plastic zone size at overload
APCOL2	Length of crack No. 2 plus plastic zone size at overload
RYAOL2	Plane strain plastic zone for crack No. 2 at overload
RYCOL2	Plane stress plastic zone for crack No. 2 at overload
AKOL2	Depth direction K_{max} for crack No. 2 at overload
CKOL2	Surface direction K_{max} for crack No. 2 at overload
AOL2	Depth of crack No. 2 at overload
COL2	Length of crack No. 2 at overload

REMARKS (1) Executable when Method 1 is used.

(2) Initial values are equal to 0.0.

FILE 1: INPUT DATA CARD NO. 9

DESCRIPTION: FATIGUE DAMAGE PARAMETERS

FORMAT: 6E10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	
VARIABLE	DMG1	DMGOL1	DELOG1	DMG2	DMGOL2	DELOC2	
EXAMPLE	.333E0	.685E-04	0.0	.430E-01	.179E-05	0.0	

VARIABLE	DESCRIPTION
DMG1	Accumulated damage for site No. 1
DMGOL1	Damage at overload for site No. 1
DELOG1	Accumulated damage for site No. 1 since last overload
DMG2	Accumulated damage for site No. 2
DMGOL2	Damage at overload for site No. 2
DELOG2	Accumulated damage for site No. 2 since last overload

REMARKS (1) Executable when Method 2 is used.

(2) Initial values are equal to 0.0.

FILE 1: INPUT DATA CARD NO. 10

DESCRIPTION: MODEL GEOMETRY AND LOADING CONFIGURATION

FORMAT: 7F10.4, F5.1, F5.2

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71-75	76-80
VARIABLE	THK	RADIUS	B1	B2	BOLTM1	BOLTM2	EOD	CBK	PINDEF
EXAMPLE	0.188	0.125	2.14	0.5	0.0825	-0.0026	5.0	20.0	1.06

VARIABLE	DESCRIPTION
THK	Thickness of specimen
RADIUS	Radius of middle hole
B1	R.H.S. edge distance to mid hole
B2	L.H.S. edge distance to mid hole
BOLTM1	Fraction of load transfer by mid bolt - C_1
BOLTM2	Fraction of Load transfer by mid bolt - C_2
EOD	E/D ratio
CBK	% countersunk height
PINDEF	Pin deflection

REMARKS (1) Executable for both Methods.

FILE 1: INPUT DATA CARD NO. 11

DESCRIPTION: MODEL GEOMETRY AND LOADING CONFIGURATION

FORMAT: 8F10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
VARIABLE	RAD1	RAD2	HODIS1	HODIS2	BOLTR1	BOLTR2	BOLTL1	BOLTL2
EXAMPLE	0.125	0.0	1.64	0.0	0.0825	0.0100	0.0	0.0

<u>VARIABLE</u>	<u>DESCRIPTION</u>
RAD1	Radius of R.H.S. hole
RAD2	Radius of L.H.S. hole
HODIS1	Distance between mid and R.H.S. holes
HODIS2	Distance between mid and L.H.S. holes
BOLTR1	Fraction of load transfer in R.H.S. bolt - C_1
BOLTR2	Fraction of Load transfer in R.H.S. bolt - C_2
BOLTL1	Fraction of load transfer in L.H.S. bolt - C_1
BOLTL2	Fraction of Load transfer in L.H.S. bolt - C_2

<u>REMARKS</u> (1) Executable for both Methods.

FILE 1: INPUT DATA CARD NO. 12

DESCRIPTION: SURFACE STRESSES

FORMAT: 2F10.4

FIELD	1 - 10	11 - 20	
VARIABLE	FRICT	FAYSUR	
EXAMPLE	3.00	2.00	

VARIABLE	DESCRIPTION
FRICT	Friction stress due to fastener pre-load
FAYSUR	Faying surface friction stress

REMARKS (1) Executable for both Method 1 and Method 2

FILE 1: INPUT DATA CARD NO. 13

DESCRIPTION: SPECTRUM AND ROUTINE SELECTION

FORMAT: 8I5 (RIGHT JUSTIFIED)

FIELD	1 - 5	6 - 10	11 - 15	16 - 20	21 - 25	26- 30	31 - 35	36 - 40
VARIABLE	IRESTA	NSOLD	NCRKS	NINITS	IRETAD	NBLKS	KID	LID
EXAMPLE	0	0	1	2	1	100	1010	1010

VARIABLE	DESCRIPTION
IRESTA	1 a re-start problem, otherwise 0
NSOLD	Old step number from spectrum at stop
NCRKS	Number of crack tips
NINITS	Number of crack initiation sites
IRETAD	Code to include retardation 1, otherwise 0
NBLKS	Maximum number of blocks for analysis
KID	Stress intensity factor code KXXXX subroutine
LID	Stress concentration factor code SXXXX subroutine

<u>REMARKS</u> (1) Routines selection (Ref. Figures 2.1-1 through 2.2-6).

FILE 1: INPUT DATA CARD NO. 14

DESCRIPTION: STRINGER'S VARIABLES

FORMAT: 8F10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
VARIABLE	VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7	VAR8
EXAMPLE	1.226	1.414	0.462	1.0	0.2658	0.0	0.0	0.0

SUBROUTINE

VARIABLE	K2010	K2020	K2040	K2050	K2060
VAR1	W1	W1	W1	HTG	D
VAR2	W2	W2	W2	XBAR	XBAR
VAR3	T2	T2	T2	YBAR	YBAR
VAR4	SFJ	SFJ	SFJ	I_{XX}	I_{XX}
VAR5	CLTD	CLTD	CLTD	I_{YY}	I_{YY}
VAR6				I_{XY}	I_{XY}
VAR7				T2	TU
VAR8					

REMARKS (1) User defined variables used only with subroutines K2010, K2020, K2040, K2050 and K2060.

(2) Definition of variable reference pages 41 and 42.

FILE 1: INPUT DATA CARD NO. 15

DESCRIPTION: SPECTRUM DESCRIPTION

FORMAT: 3F10.4, I10

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	
VARIABLE	FLTBLK	BLKLIF	FLTHR	ISTRES	
EXAMPLE	120.0	25.0	6000.0	1	

VARIABLE	DESCRIPTION
FLTBLK	Total number of flights in one block
BLKLIF	Total number of blocks in one design lifetime
FLTHR	Total number of flight hours in one design lifetime
ISTRES	Flag for output of stress spectrum (=1 if desired)

REMARKS (1) Non executable variables.

FILE 2: INPUT DATA CARD NO. 1

DESCRIPTION: LOADING SPECTRUM

FORMAT: 3F10.3

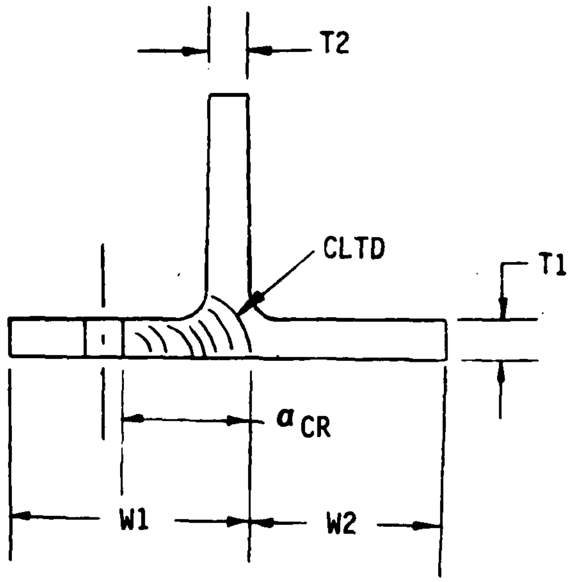
FIELD	0 - 10	11 - 20	21 - 30	
VARIABLE	SIGMAX(I)	SIGMIN(I)	CYC(I)	
EXAMPLE	21.7	- 5.0	135.0	
	35.0	21.0	3.0	

VARIABLE	DESCRIPTION
SIGMAX(I)	Maximum stress level
SIGMIN(I)	Minimum stress level
CYC(I)	Number of cycles in the layer

REMARKS (1) Maximum 3000 stress layers.

TABLE 2.3-2. VARIABLES DEFINITION OF SUBROUTINES K2010, K2020 AND K2040

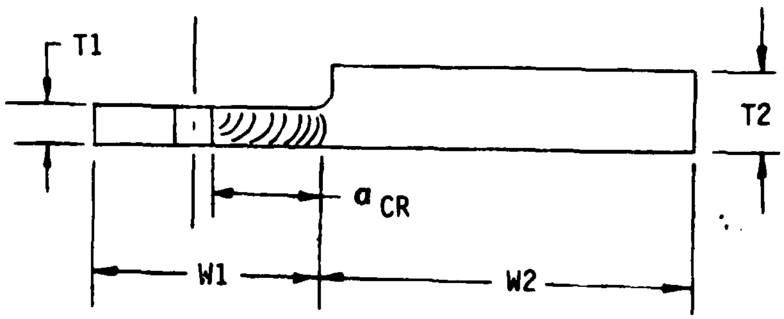
(a) 'TEE' SECTION



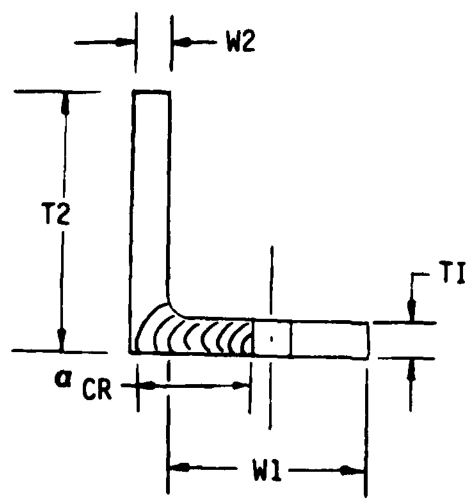
$$CLTD = (T1^2 + T2^2)^{1/2}$$

SFJ = 0 Crack grows toward upstanding leg

= 1 Crack growth away from upstanding leg



(b) 'L' SECTION



CLTD = W2 if $W2 \geqslant T1$

CLTD = T1 if $T1 > W2$

TABLE 2.3-3. VARIABLE DEFINITIONS OF SUBROUTINE K2050

HGT = Stringer Height

XBAR = $\bar{x}$

YBAR = $\bar{y}$

I_{xx} = moment of inertia x - x

I_{yy} = moment of inertia y - y

I_{xy} = product of inertia x - y

TU = Thickness of upstanding leg

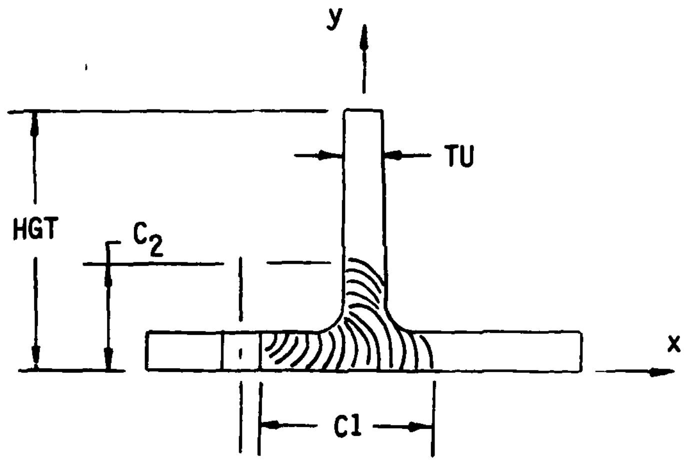


TABLE 2.3-4. VARIABLE DEFINITION OF SUBROUTINE K2060

D = Distance from ℄ of hole to outer surface of upstanding leg

XBAR = $\bar{x}$

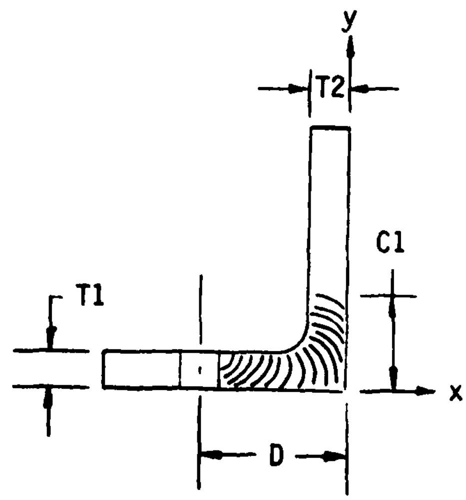
YBAR = $\bar{y}$

I_{xx} = moment of inertia x - x

I_{yy} = moment of inertia y - y

I_{xy} = product of inertia x - y

T2 = Thickness of upstanding leg



3.0 EXAMPLE RUNS

This section presents three (3) examples to illustrate the usage of DAMGRO Computer Program. They include the following:

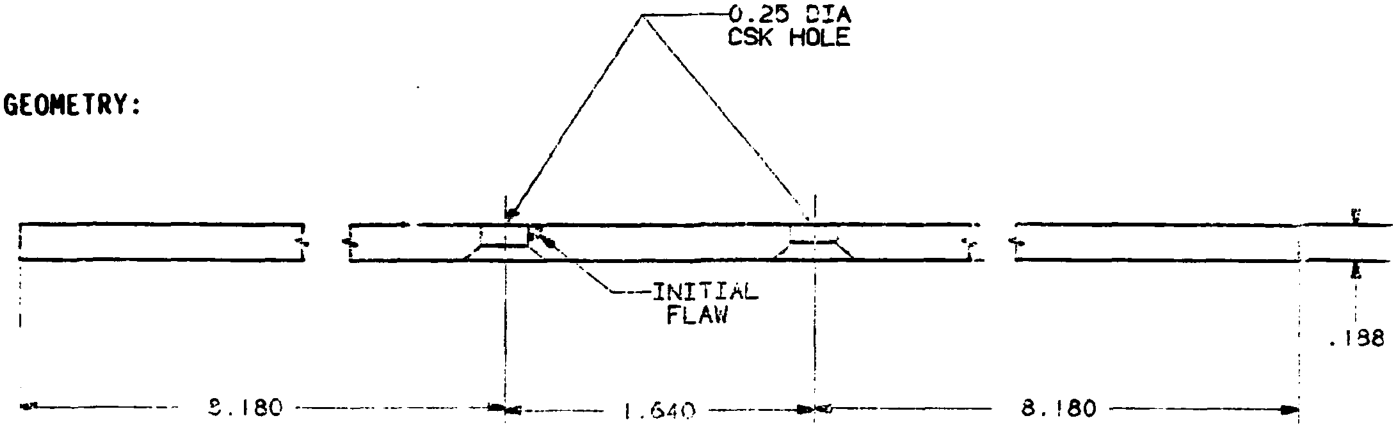
(1) Skin section subjected to a constant amplitude loading, with maximum gross stress of 17.0 KSI, R = 0.10 (Ref. pages 44 through 65).

(2) Skin section subjected to a randomized loading spectrum. The modified Willenborg model was applied (Ref. pages 66 through 90).

(3) Stringer section subjected to a constant amplitude loading spectrum, with maximum gross stress of 17.0 KSI, R = 0.10 (Ref. pages 91 through 107).

EXAMPLE 1: SKIN SECTION SUBJECTED TO CONSTANT AMPLITUDE LOADING

GEOMETRY:



MATERIAL:

2024-T3 SHEET

LOADING SPECTRUM:

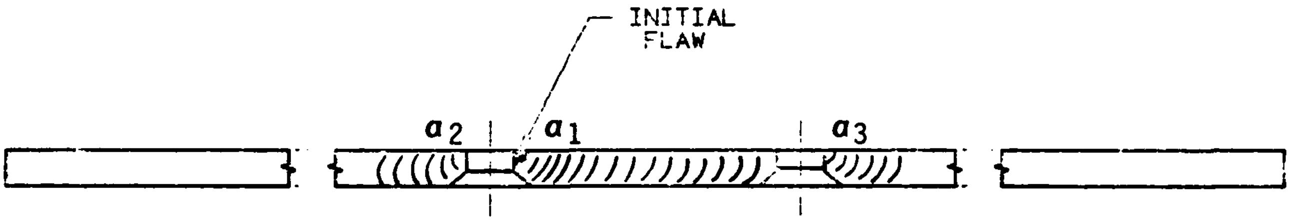
CONSTANT AMPLITUDE

σ_{max} = 17.0 KSI σ_{min} = 1.7 KSI

REF. PAGES 45 THROUGH 65

TABLE 3.1.1. EXAMPLE 1, METHOD 1 SUMMARY TABLE

REF. PAGES 46 THROUGH 51



a_1 (IN)	a_2 (IN)	a_3 (IN)	LIFE (CYCLES)	ROUTINE GROWTH	RUN NO.
.050	0	.005	0	K1010	1
.102	0		10,000	K1010	1
.220	0		20,000	K1010	1
.419	0		30,000	K1010	1
.788	0		40,000	K1010	1
1.39	0		46,625	K1010	1
	0	.380	48,025	K1030	2
	0	1.034	50,025	K1030	2
	0	1.955	52,625	K1030	2
	0	3.484	54,625	K1030	2
	0	7.303	56,198	K1030	2

NO. OF CYCLES TO FAILURE = 56,198 CYCLES

TABLE 3.1.1-1. EXAMPLE 1, METHOD 1, RUN 1 INPUT FILE

```
 EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMLITUDE LOADING SPECTRUM
2024-13  SHEET
2.2374E-09       0.70    3.3386 6.2126E-9      0.00     2.9783
    116.00       36.0      53.0       2.0       2.3       0.99     -0.99
    10.426      -.366     0.887   10700.0     0.022      1.000       1.0       1.0
     0.050      1.390     0.050     0.188     .0000      0.000     0.000     0.000
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
     0.188     0.1250      8.18      9.82   0.00000     .00000    99.900  50. 1.00
    0.0000     0.1250      0.00      1.64   0.00000     .00000   0.00000    .00000
    0.000      0.0000
    0   00     1    0     1  100 1010 0000
     0.000      0.000     0.000     0.000     0.000      0.000     0.000     0.000
     120.0       25.0     6000.         1
```

TABLE 3.1.1-2. EXAMPLE 1, METHOD 1, RUN 1 OUTPUT FILE

```
      *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM   D A M G R O  *****

  EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM

     * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED :    CRACK GROWTH =    1;  CRACK INITIATION =    0
 CORRESPONDING DAMAGE CODES :    CRACK GROWTH = 1010;  CRACK INITIATION =    0

LOAD INTERACTION :       NONE

MATERIAL :    2024-T3  SHEET
    WALKER EQ. CONST. (+R) :  C = 0.224E-08,  M =0.700,  N =3.339
    WALKER EQ. CONST. (-R) :  C = 0.621E-08,  M =0.000,  N =2.978
    MAX.  K  FOR DC/DN THRESHOLD = 2.000
    RETARDATION SHUT-OFF RATIO = 2.300
    +R CUT-OFF = 0.9900,   -R CUT-OFF = -0.9900
    YIELD STRENGTH :  53.000
    ELASTIC MODULUS = 0.1070E+05
    PL. STRESS FRACT. TOUGHNESS =  116.00
    PL. STRAIN FRACT. TOUGHNESS = 36.00
    DAMAGE INDEX FOR CRACK INITIATION =  0.892
    NEUBER MATERIAL CONST. = 0.022
    CRACK INITIATION EQ. CONST. :  SF = 10.426,  M =-.366
    STRESS SEVERITY FACTOR PARAMETERS :
      ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :
    INITIAL CRACK LENGTH OF CRACK NO. 1 :   0.05000
    FINAL CRACK LENGTH OF CRACK NO. 1 :     1.39000
    INITIAL CRACK DEPTH OF CRACK NO. 1 :    0.05000
    FINAL CRACK DEPTH OF CRACK NO. 1 :      0.18800
    INITIAL CRACK LENGTH OF CRACK NO. 2 :   0.00000
    FINAL CRACK LENGTH OF CRACK NO. 2 :     0.00000
    INITIAL CRACK DEPTH OF CRACK NO. 2      0.00000
    FINAL CRACK DEPTH OF CRACK NO. 2 :      0.00000
    PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+0C
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY
        DMG1 = .000E+00, DMGOL1 =.000E+00,  DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.1.1-2. EXAMPLE 1, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

```
COMPONENT GEOMETRY :
    THICKNESS OF PLATE :                                    0.18800
    RADIUS OF MID. HOLE :                                   0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :          99.89999
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :            9.82000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :            8.18000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :                0.00000,  0.00000
    RADIUS OF THE R.H.S. HOLE :                             0.12500
    DISTANCE BETWEEN MID. AND R.H.S. HOLES :                1.64000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :              0.00000,  0.00000
    RADIUS OF THE L.H.S. HOLE :                             0.00000
    DISTANCE BETWEEN MID. AND L.H.S. HOLES :                0.00000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :              0.00000,  0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :      20.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION :            1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS :               0.0000
    FAYING SURFACE FRICTION STRESS :                        0.0000

STRESS SPECTRUM :
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                  100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                    10000.000
    TOTAL NO. OF FLIGHTS IN ONE BLOCK :                     120.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME :                   25.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :           6000.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM :                    17.000
    NO. OF STRESS LAYERS IN ONE BLOCK                        10

STRESS LAYERS IN ONE BLOCK :
    STEP SIGMA-MAX  SIGMA-MIN   CYCLES       STEP SIGMA-MAX  SIGMA-MIN   CYCLES
      1    17.000      1.700 1000.000          2    17.000      1.700 1000.000
      3    17.000      1.700 1000.000          4    17.000      1.700 1000.000
      5    17.000      1.700 1000.000          6    17.000      1.700 1000.000
      7    17.000      1.700 1000.000          8    17.000      1.700 1000.000
      9    17.000      1.700 1000.000         10    17.000      1.700 1000.000
```

TABLE 3.1.1-2. EXAMPLE 1, METHOD 1, RUN 1 OUTPUT FILE (CONCLUDED)

```
       *******   D A M A G E   G R O W T H   H I S T O R Y   *******

BLOCK        C1        C2    KMAX-C1  KMAX-C2    DC1/DF     DC2/DF    INITIA1    INITIA2
             A1        A2    KMAX-A1  KMAX-A2    DA1/DF     DA2/DF        KN1        KN2
  0.0   0.05000   0.00000      9.054    0.000  .000E+00   .000E+00   .000E+00   .000E+00
        0.05000   0.00000     11.348    0.000  .000E+00   .000E+00   .000E+00   .000E+00
  1.0   0.10203   0.00000     12.570    0.000  .434E-03   .000E+00   .000E+00   .000E+00
        0.13103   0.00000     13.606    0.000  .675E-03   .000E+00   .000E+00   .000E+00

STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :
    CYC=  135.0,    STEP =    6,    BLOCK =    2,    CRACK DEPTH = 0.18805
CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS  0.1880  INCHES

  2.0   0.22022   0.00000     15.227    0.000  .985E-03   .000E+00   .000E+00   .000E+00
        0.18800   0.00000      0.000    0.000  .475E-03   .000E+00   .000E+00   .000E+00
  3.0   0.41962   0.00000     17.733    0.000  .166E-02   .000E+00   .000E+00   .000E+00
        0.18800   0.00000      0.000    0.000  .000E+00   .000E+00   .000E+00   .000E+00
  4.0   0.78810   0.00000     22.009    0.000  .307E-02   .000E+00   .000E+00   .000E+00
        0.18800   0.00000      0.000    0.000  .000E+00   .000E+00   .000E+00   .000E+00

CRACK NO. 1 HAS REACHED THE SPECIFIED LENGTH  1.3900  INCHES AT :
    CYC = 625.0,    STEP =    7,    BLOCK =    5,   CKMAXS= 63.24,   C1= 1.39096
TERMINATE DAMAGE COMPUTATION

    CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
          C1 = 1.39096,    A1 = 0.18800,    C2 = 0.00000,    A2 = 0.00000


    RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
        DMG1 = .000E+00, DMGOL1 =.000E+00,  DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.1.1-3. EXAMPLE 1, METHOD 1, RUN 2 INPUT FILE

```
 EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMLITUDE LOADING SPECTRUM
2024-T3  SHEET
2.2374E-09      0.70    3.3386 6.2126E-9      0.00    2.9783
   116.00       36.0      53.0       2.0       2.3      0.99     -0.99
  10.426      -.366      0.887   10700.0     0.022     1.000       1.0       1.0
  0.055       8.180      0.072     0.188     .0000     0.000     0.000     0.000
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
    0.188     0.1250      8.18      9.82   0.00000    .00000    99.900  50. 1.00
   0.0000     0.1250      0.00      1.64   0.00000    .00000   0.00000   .00000
   0.000      0.0000
   0   00     1    0     1  100 1030 0000
    0.000      0.000     0.000     0.000     0.000     0.000     0.000     0.000
    120.0       25.0     6000.         1
```

TABLE 3.1.1-4. EXAMPLE 1, METHOD 1, RUN 2 OUTPUT FILE

```
      *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM    D A M G R O  *****

  EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM

     * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

 NO. OF SITES TO BE ANALYZED :    CRACK GROWTH =     1;  CRACK INITIATION =    0
  CORRESPONDING DAMAGE CODES :    CRACK GROWTH = 1030;  CRACK INITIATION =    0

 LOAD INTERACTION :        NONE

 MATERIAL :    2024-T3  SHEET
     WALKER EQ. CONST. (+R) :  C = 0.224E-08,  M =0.700,  N =3.339
     WALKER EQ. CONST. (-R) :  C = 0.621E-08,  M =0.000,  N =2.978
     MAX.  K  FOR DC/DN THRESHOLD = 2.000
     RETARDATION SHUT-OFF RATIO = 2.300
     +R CUT-OFF = 0.9900,    -R CUT-OFF = -0.9900
     YIELD STRENGTH :  53.000
     ELASTIC MODULUS = 0.1070E+05
     PL. STRESS FRACT. TOUGHNESS =  116.00
     PL. STRAIN FRACT. TOUGHNESS = 36.00
     DAMAGE INDEX FOR CRACK INITIATION =  0.892
     NEUBER MATERIAL CONST. = 0.022
     CRACK INITIATION EQ. CONST.    SF =  10.426,  M =-.366
     STRESS SEVERITY FACTOR PARAMETERS :
       ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

 SPECIFIED DAMAGE CONDITIONS :
     INITIAL CRACK LENGTH OF CRACK NO. 1 :    0.05500
     FINAL CRACK LENGTH OF CRACK NO. 1 :      8.18000
     INITIAL CRACK DEPTH OF CRACK NO. 1 :     0.07200
     FINAL CRACK DEPTH OF CRACK NO. 1 :       0.18800
     INITIAL CRACK LENGTH OF CRACK NO. 2 :    0.00000
     FINAL CRACK LENGTH OF CRACK NO. 2 :      0.00000
     INITIAL CRACK DEPTH OF CRACK NO. 2       0.00000
     FINAL CRACK DEPTH OF CRACK NO. 2 :       0.00000
     PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY
       APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
        AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
       APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
        AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
     PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY
         DMG1 = .000E+00, DMGOL1 = .000E+00,  DELDG1 = .000E+00
         DMG2 = .000E+00, DMGOL2 = .000E+00,  DELDG2 = .000E+00
```

TABLE 3.1.1-4. EXAMPLE 1, METHOD 1, RUN 2 OUTPUT FILE (CON'T.)

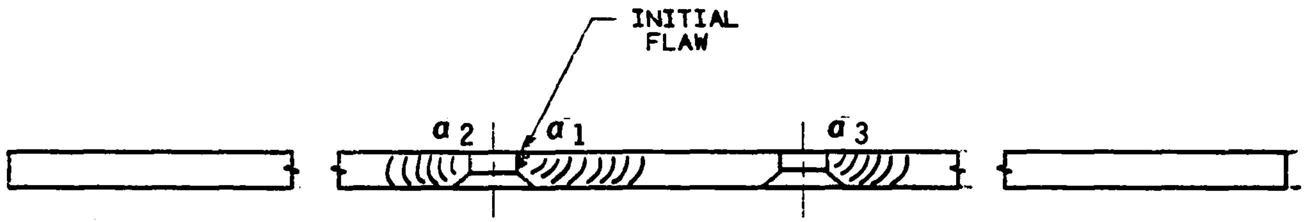
```
COMPONENT GEOMETRY
    THICKNESS OF PLATE :                                   0.18800
    RADIUS OF MID. HOLE :                                  0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :         99.89999
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :           8.18000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :           9.82000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :               0.00000,   0.00000
    RADIUS OF THE R.H.S. HOLE :                            0.00000
    DISTANCE BETWEEN MID. AND R.H.S. HOLES :               0.00000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :             0.00000,   0.00000
    RADIUS OF THE L.H.S. HOLE :                            0.12500
    DISTANCE BETWEEN MID. AND L.H.S. HOLES :               1.64000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :             0.00000,   0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS       20.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION :           1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS :              0.0000
    FAYING SURFACE FRICTION STRESS :                       0.0000

STRESS SPECTRUM :
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                 100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                  2000.000
    TOTAL NO. OF FLIGHTS IN ONE BLOCK :                  120.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME :                25.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :        6000.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM :                 1[illegible].000
    NO. OF STRESS LAYERS IN ONE BLOCK                      2
```

TABLE 3.1.1-4. EXAMPLE 1, METHOD 1, RUN 2 OUTPUT FILE (CONCLUDED)

```
STRESS LAYERS IN ONE BLOCK :
    STEP SIGMA-MAX  SIGMA-MIN   CYCLES        STEP SIGMA-MAX  SIGMA-MIN   CYCLES
      1    17.000       1.700 1000.000          2    17.000       1.700 1000.000

STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :
    CYC=  946.0,     STEP =    1,    BLOCK =    1,    CRACK DEPTH = 0.18893
CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS  0.1880  INCHES

  0.0  0.05500  0.00000   23.358    0.000  .000E+00  .000E+00  .000E+00  .000E+00
       0.07200  0.00000   25.781    0.000  .000E+00  .000E+00  .000E+00  .000E+00
  1.0  0.38048  0.00000   35.380    0.000  .271E-02  .000E+00  .000E+00  .000E+00
       0.18800  0.00000    0.000    0.000  .967E-03  .000E+00  .000E+00  .000E+00
  2.0  1.03462  0.00000   39.558    0.000  .545E-02  .000E+00  .000E+00  .000E+00
       0.18800  0.00000    0.000    0.000  .000E+00  .000E+00  .000E+00  .000E+00
  3.0  1.95571  0.00000   44.499    0.000  .768E-02  .000E+00  .000E+00  .000E+00
       0.18800  0.00000    0.000    0.000  .000E+00  .000E+00  .000E+00  .000E+00
  4.0  3.48375  0.00000   54.072    0.000  .127E-01  .000E+00  .000E+00  .000E+00
       0.18800  0.00000    0.000    0.000  .000E+00  .000E+00  .000E+00  .000E+00

UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:
    CYC = 573.0,   STEP =   2,   BLOCK =   5,   CRACK LENGTH = 7.30257,   CKMAXS=116.4
THE OTHER CRACK LENGTH = 0.00000
TERMINATE DAMAGE COMPUTATION


    RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION
        DMG1 = .000E+00, DMGOL1 =.000E+00,   DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,   DELDG2 =.000E+00
```

TABLE 3.1.2. EXAMPLE 1, METHOD 2 SUMMARY TABLE

REF. PAGES 53 THROUGH 65



a 1 (IN)	a 2 (IN)	a 3 (IN)	LIFE (CYCLES)	ROUTINES GROWTH	ROUTINES INITIATION	RUN NO.
.050	0	0	0	K1010	S1010	1
.102	0	0	10,000	K1010	S1010	1
.220	0	0	20,000	K1010	S1010	1
.419	0	0	30,000	K1010	S1010	1
.788	0	0	40,000	K1010	S1010	1
.904	0	0	42,000	K1010	S1010	1
1.048	0	0	44,000	K1010	S1010	1
1.246	0	0	46,000	K1010	S1010	1
1.39	0	0	46,625	K1010	S1010	1
	.050	0	51,625	-	S1040	2
	.330	0	53,625	K1030	S1050	3
	.961	0	55,625	K1030	S1050	3
	1.364	0.050	56,625	K1030	S1050	3
	2.618	1.233	58,625	K1050	-	4
	3.254	4.572	59,625	K1050	-	4

NO. OF CYCLES TO SECONDARY CRACK INITIATION = 51,625 CYCLES
NO. OF CYCLES TO FAILURE = 59,625 CYCLES

TABLE 3.1.2-1. EXAMPLE 1, METHOD 2, RUN 1 INPUT FILE

```
 EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMLITUDE LOADING SPECTRUM
2024-T3  SHEET
2.2374E-09      0.70     3.3386 6.2126E-9      0.00     2.9783
   116.00       36.0       53.0       2.0        2.3       0.99     -0.99
   10.426      -.366      0.892   10700.0      0.022      1.000       1.0       1.0
   0.050       1.390      0.050     0.188      .0000      0.000     0.000     0.000
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
     0.188     0.1250      8.18      9.82    0.00000     .00000     99.900  50. 1.00
    0.0000     0.1250      0.00      1.64    0.00000     .00000    0.00000    .00000
    0.000      0.0000
    0   00     1    2     1  100 1010 1010
     0.000      0.000     0.000     0.000      0.000      0.000     0.000     0.000
     120.0       25.0     6000.         1
```

TABLE 3.1.2-2. EXAMPLE 1, METHOD 2, RUN 1 OUTPUT FILE

```
      *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM    D A M G R O  *****

  EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM

     * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

 NO. OF SITES TO BE ANALYZED :    CRACK GROWTH =    1;  CRACK INITIATION =    2
  CORRESPONDING DAMAGE CODES :    CRACK GROWTH = 1010;  CRACK INITIATION = 1010

 LOAD INTERACTION :       NONE

 MATERIAL :    2024-T3  SHEET
     WALKER EQ. CONST. (+R) :   C = 0.224E-08,  M =0.700,  N =3.339
     WALKER EQ. CONST. (-R) :   C = 0.621E-08,  M =0.000,  N =2.978
     MAX.  K  FOR DC/DN THRESHOLD = 2.000
     RETARDATION SHUT-OFF RATIO = 2.300
     +R CUT-OFF = 0.9900,     -R CUT-OFF = -0.9900
     YIELD STRENGTH :   53.000
     ELASTIC MODULUS = 0.1070E+05
     PL. STRESS FRACT. TOUGHNESS =  116.00
     PL. STRAIN FRACT. TOUGHNESS = 36.00
     DAMAGE INDEX FOR CRACK INITIATION =  0.892
     NEUBER MATERIAL CONST. = 0.022
     CRACK INITIATION EQ. CONST. :  SF = 10.426,  M =-.366
     STRESS SEVERITY FACTOR PARAMETERS
       ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

 SPECIFIED DAMAGE CONDITIONS :
     INITIAL CRACK LENGTH OF CRACK NO. 1 :    0.05000
     FINAL CRACK LENGTH OF CRACK NO. 1 :      1.39000
     INITIAL CRACK DEPTH OF CRACK NO. 1 :     0.05000
     FINAL CRACK DEPTH OF CRACK NO. 1 :       0.18800
     INITIAL CRACK LENGTH OF CRACK NO. 2 :    0.00000
     FINAL CRACK LENGTH OF CRACK NO. 2 :      0.00000
     INITIAL CRACK DEPTH OF CRACK NO. 2 :     0.00000
     FINAL CRACK DEPTH OF CRACK NO. 2 :       0.00000
     PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY
       APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
        AKOL1 = .000E+00,  CKOL1 = .000E+00,   GOL1 = .000E+00,   COL1 = .000E+00
       APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
        AKOL2 = .000E+00,  CKOL2 = .000E+00,   GOL2 = .000E+00,   COL2 = .000E+00
     PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :
         DMG1 = .000E+00, DMGOL1 = .000E+00,  DELDG1 = .000E+00
         DMG2 = .000E+00, DMGOL2 =.000E+00,   DELDG2 = .000E+00
```

TABLE 3.1.2-2. EXAMPLE 1, METHOD 2, RUN 1 OUTPUT FILE (CON'T.)

```
COMPONENT GEOMETRY
     THICKNESS OF PLATE                                       0.18800
     RADIUS OF MID  HOLE                                      0.12500
     RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :           99.89999
     DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :             9.82000
     DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE               8.18000
     FRACTION OF LOAD TRANSFER BY MID. BOLT                   0.00000    0.00000
     RADIUS OF THE R.H.S. HOLE                                0.12500
     DISTANCE BETWEEN MID. AND R.H.S. HOLES :                 1.64000
     FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :               0.00000,   0.00000
     RADIUS OF THE L.H.S. HOLE                                0.00000
     DISTANCE BETWEEN MID. AND L.H.S. HOLES :                 0.00000
     FRACTION OF LOAD TRANSFER BY L.H.S. BOLT                 0.00000,   0.00000
     PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :       20.0
     STRESS CONCENTRATION DUE TO PIN DEFLECTION :             1.00
     FASTENER HEAD OR COLLAR FRICTION STRESS                  0.0000
     FAYING SURFACE FRICTION STRESS :                         0.0000

STRESS SPECTRUM
     NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                   100
     TOTAL NO. OF CYCLES IN ONE BLOCK :                      2000.000
     TOTAL NO. OF FLIGHTS IN ONE BLOCK :                      120.000
     NO. OF BLOCKS IN ONE DESIGN LIFETIME :                    25.000
     NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME              6000.000
     MAXIMUM PEAK STRESS OF THE SPECTRUM :                     17.000
     NO. OF STRESS LAYERS IN ONE BLOCK                          2

STRESS LAYERS IN ONE BLOCK :
     STEP SIGMA-MAX  SIGMA-MIN   CYCLES        STEP SIGMA-MAX  SIGMA-MIN   CYCLES
       1     17.000      1.700 1000.000          2     17.000      1.700 1000.000
```

TABLE 3.1.2-2. EXAMPLE 1, METHOD 2, RUN 1 OUTPUT FILE (CON'T.)

******* D A M A G E   G R O W T H   H I S T O R Y *******

BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
0.0	0.05000	0.00000	9.054	0.000	.000E+00	.000E+00	.252E-02	[illegible]
	0.05000	0.00000	11.348	0.000	.000E+00	.000E+00	.264E+01	.250E+01
1.0	0.05630	0.00000	9.860	0.000	.525E-04	.000E+00	.269E-02	.260E-02
	0.06240	0.00000	11.820	0.000	.103E-03	.000E+00	.266E+01	.250E+01
2.0	0.06449	0.00000	10.579	0.000	.682E-04	.000E+00	.131E-01	.933E-02
	0.07658	0.00000	12.290	0.000	.118E-03	.000E+00	.268E+01	.250E+01
3.0	0.07468	0.00000	11.249	0.000	.850E-04	.000E+00	.188E-01	.131E-01
	0.09268	0.00000	12.751	0.000	.134E-03	.000E+00	.270E+01	.250E+01
4.0	0.08709	0.00000	11.902	0.000	.107E-03	.000E+00	.248E-01	.168E-01
	0.11082	0.00000	13.192	0.000	.151E-03	.000E+00	.274E+01	.250E+01
5.0	0.10203	0.00000	12.570	0.000	.124E-03	.000E+00	.313E-01	.205E-01
	0.13103	0.00000	13.606	0.000	.168E-03	.000E+00	.278E+01	.250E+01
6.0	0.11997	0.00000	13.282	0.000	.149E-03	.000E+00	.384E-01	.243E-01
	0.15333	0.00000	13.987	0.000	.186E-03	.000E+00	.282E+01	.250E+01
7.0	0.13949	0.00000	13.429	0.000	.163E-03	.000E+00	.448E-01	.280E-01
	0.17540	0.00000	13.725	0.000	.184E-03	.000E+00	.276E+01	.250E+01

STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :
CYC= 135.0, STEP = 2, BLOCK = 8, CRACK DEPTH = 0.18805
CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS 0.1880 INCHES

8.0	0.16290	0.00000	14.511	0.000	.195E-03	.000E+00	.518E-01	.317E-01
	0.18800	0.00000	0.000	0.000	.105E-03	.000E+00	.282E+01	.250E+01
9.0	0.19041	0.00000	14.852	0.000	.229E-03	.000E+00	.597E-01	.355E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.288E+01	.250E+01
10.0	0.22022	0.00000	15.227	0.000	.248E-03	.000E+00	.684E-01	.392E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.295E+01	.250E+01
11.0	0.25265	0.00000	15.637	0.000	.270E-03	.000E+00	.787E-01	.429E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.302E+01	.250E+01
12.0	0.28822	0.00000	16.088	0.000	.296E-03	.000E+00	.903E-01	[illegible]
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.309E+01	.250E+01
13.0	0.32744	0.00000	16.584	0.000	.327E-03	.000E+00	.104E+00	[illegible]
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	[illegible]	[illegible]
14.0	0.37097	0.00000	17.130	0.000	.363E-03	.000E+00	.119E+00	.541E-01

TABLE 3.1.2-2. EXAMPLE 1, METHOD 2, RUN 1 OUTPUT FILE (CONCLUDED)

```
        0.18800  0.00000    0.000   0.000  .000E+00  .000E+00  .326E+01  .250E+01
 15.0   0.41962  0.00000   17.733   0.000  .405E-03  .000E+00  .137E+00  .579E-01
        0.18800  0.00000    0.000   0.000  .000E+00  .000E+00  .335E+01  .250E+01
 16.0   0.47447  0.00000   18.430   0.000  .457E-03  .000E+00  .158E+00  .616E-01
        0.18800  0.00000    0.000   0.000  .000E+00  .000E+00  .345E+01  .250E+01
 17.0   0.53670  0.00000   19.143   0.000  .519E-03  .000E+00  .183E+00  .653E-01
        0.18800  0.00000    0.000   0.000  .000E+00  .000E+00  .356E+01  .250E+01
 18.0   0.60812  0.00000   19.976   0.000  .595E-03  .000E+00  .212E+00  .691E-01
        0.18800  0.00000    0.000   0.000  .000E+00  .000E+00  .367E+01  .250E+01
 19.0   0.69090  0.00000   20.920   0.000  .690E-03  .000E+00  .249E+00  .728E-01
        0.18800  0.00000    0.000   0.000  .000E+00  .000E+00  .382E+01  .250E+01
 20.0   0.78810  0.00000   22.009   0.000  .810E-03  .000E+00  .294E+00  .765E-01
        0.18800  0.00000    0.000   0.000  .000E+00  .000E+00  .398E+01  .250E+01
 21.0   0.90453  0.00000   23.313   0.000  .970E-03  .000E+00  .350E+00  .803E-01
        0.18800  0.00000    0.000   0.000  .000E+00  .000E+00  .416E+01  .250E+01
 22.0   1.04848  0.00000   25.039   0.000  .120E-02  .000E+00  .424E+00  .840E-01
        0.18800  0.00000    0.000   0.000  .000E+00  .000E+00  .436E+01  .250E+01

CRACK NO. 1 HAS REACHED THE SPECIFIED LENGTH  1.3900  INCHES AT .
    CYC = 625.0,    STEP =    1,   BLOCK =  24,  CKMAXS= 63.24,  C1= 1.39096
TERMINATE DAMAGE COMPUTATION
 23.0   1.24675  0.00000   29.167   0.000  .165E-02  .000E+00  .525E+00  .877E-01
        0.18800  0.00000    0.000   0.000  .000E+00  .000E+00  .464E+01  .250E+01

     CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION
           C1 = 1.39096,   A1 = 0.18800,   C2 = 0.00000,   A2 = 0.00000


     RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION
       APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
        AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
       APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
        AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
     RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION
         DMG1 = .525E+00, DMGOL1 =.000E+00,  DELN1 =.000E+00
         DMG2 = .877E-01, DMGOL2 =.000E+00,  DELN2 =.000E+00
```

TABLE 3.1.2-3. EXAMPLE 1, METHOD 2, RUN 2 INPUT FILE

```
 EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMLITUDE LOADING SPECTRUM
2024-T3  SHEET
2.2374E-09        0.70      3.3386 6.2126E-9       0.00     2.9783
    116.00        36.0        53.0        2.0        2.3       0.99     -0.99
    10.426       -.366       0.892    10700.0      0.022      1.000       1.0        1.0
     0.000       0.000       0.000      0.000      .0000      0.000     0.000      0.000
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.5250E+000.0000E+000.0000E+000.8770E-010.0000E+000.0000E+00
     0.188      0.1250        8.18       9.82    0.00000     .00000    99.900  50. 1.00
    0.0000      0.1250        0.00       1.64    0.00000     .00000   0.00000     .00000
    0.000       0.0000
    0   00      0    2      0  100 0000 1040
     0.000       0.000       0.000      0.000      0.000      0.000     0.000      0.000
     120.0        25.0       6000.          1
```

TABLE 3.1.2-4. EXAMPLE 1, METHOD 2, RUN 2 OUTPUT FILE

```
     *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM   D A M G R O  *****

  EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM

     * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED :   CRACK GROWTH =     0;  CRACK INITIATION =     2
 CORRESPONDING DAMAGE CODES :   CRACK GROWTH =     0;  CRACK INITIATION = 1040

LOAD INTERACTION :       NONE

MATERIAL :    2024-T3  SHEET
    WALKER EQ. CONST. (+R)  :  C = 0.224E-08,  M =0.700,  N =3.339
    WALKER EQ. CONST. (-R)  :  C = 0.621E-08,  M =0.000,  N =2.978
    MAX.  K  FOR DC/DN THRESHOLD = 2.000
    RETARDATION SHUT-OFF RATIO = 2.300
    +R CUT-OFF = 0.9900,    -R CUT-OFF = -0.9900
    YIELD STRENGTH :   53.000
    ELASTIC MODULUS = 0.1070E+05
    PL. STRESS FRACT. TOUGHNESS =  116.00
    PL. STRAIN FRACT. TOUGHNESS = 36.00
    DAMAGE INDEX FOR CRACK INITIATION =  0.892
    NEUBER MATERIAL CONST. = 0.022
    CRACK INITIATION EQ. CONST. :  SF = 10.426,  M =-.366
    STRESS SEVERITY FACTOR PARAMETERS :
      ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :
    INITIAL CRACK LENGTH OF CRACK NO. 1 :    0.00000
    FINAL CRACK LENGTH OF CRACK NO. 1 :      0.00000
    INITIAL CRACK DEPTH OF CRACK NO. 1       0.00000
    FINAL CRACK DEPTH OF CRACK NO. 1 :       0.00000
    INITIAL CRACK LENGTH OF CRACK NO. 2 :    0.00000
    FINAL CRACK LENGTH OF CRACK NO. 2 :      0.00000
    INITIAL CRACK DEPTH OF CRACK NO. 2 :     0.00000
    FINAL CRACK DEPTH OF CRACK NO. 2 :       0.00000
    PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :
        DMG1 = .525E+00, DMGOL1 =.000E+00,  DELDG1 = .000E+00
        DMG2 = .877E-01, DMGOL2 = .000E+00,  DELDG2 = .000E+00
```

TABLE 3.1.2-4. EXAMPLE 1, METHOD 2, RUN 2 OUTPUT FILE (CON'T.)

```
COMPONENT GEOMETRY :
     THICKNESS OF PLATE :                                      0.18800
     RADIUS OF MID. HOLE :                                     0.12500
     RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D              99.89999
     DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE                9.82000
     DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :              8.18000
     FRACTION OF LOAD TRANSFER BY MID. BOLT :                  0.00000,    0.00000
     RADIUS OF THE R.H.S. HOLE :                               0.12500
     DISTANCE BETWEEN MID. AND R.H.S. HOLES :                  1.64000
     FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :                0.00000,    0.00000
     RADIUS OF THE L.H.S. HOLE                                 0.00000
     DISTANCE BETWEEN MID. AND L.H.S. HOLES :                  0.00000
     FRACTION OF LOAD TRANSFER BY L.H.S. BOLT                  0.00000,    0.00000
     PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS          20.0
     STRESS CONCENTRATION DUE TO PIN DEFLECTION                1.00
     FASTENER HEAD OR COLLAR FRICTION STRESS                   0.0000
     FAYING SURFACE FRICTION STRESS                            0.0000

STRESS SPECTRUM :
     NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                    100
     TOTAL NO. OF CYCLES IN ONE BLOCK                         2000.000
     TOTAL NO. OF FLIGHTS IN ONE BLOCK :                       120.000
     NO. OF BLOCKS IN ONE DESIGN LIFETIME :                     25.000
     NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :             6000.000
     MAXIMUM PEAK STRESS OF THE SPECTRUM                        17.000
     NO. OF STRESS LAYERS IN ONE BLOCK                           2
```

TABLE 3.1.2-4. EXAMPLE 1, METHOD 2, RUN 2 OUTPUT FILE (CONCLUDED)

STRESS LAYERS IN ONE BLOCK :

STEP	SIGMA-MAX	SIGMA-MIN	CYCLES	STEP	SIGMA-MAX	SIGMA-MIN	CYCLES
1	17.000	1.700	1000.000	2	17.000	1.700	1000.000

******* D A M A G E   G R O W T H   H I S T O R Y *******

BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
0.0	0.00000	0.00000	0.000	0.000	.000E+00	.000E+00	.600E+00	.163E+00
	0.00000	0.00000	0.000	0.000	.000E+00	.000E+00	.492E+01	.492E+01
1.0	0.00000	0.00000	0.000	0.000	.000E+00	.000E+00	.752E+00	.314E+00
	0.00000	0.00000	0.000	0.000	.000E+00	.000E+00	.492E+01	.492E+01

CRACK INITIATION FOR LOCATION 1 OCCURS AT :
CYC =1000.000, STEP = 1, BLOCK = 3

2.0	0.00000	0.00000	0.000	0.000	.000E+00	.000E+00	.827E+00	.466E+00
	0.00000	0.00000	0.000	0.000	.000E+00	.000E+00	.492E+01	.492E+01

CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
C1 = 0.00000, A1 = 0.00000, C2 = 0.00000, A2 = 0.00000

RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION
APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00
APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00
RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION
DMG1 = .827E+00, DMGOL1 =.000E+00, DELDG1 = .000E+00
DMG2 = .466E+00, DMGOL2 =.000E+00, DELDG2 = .000E+00

TABLE 3.1.2-5. EXAMPLE 1, METHOD 2, RUN 3 INPUT FILE

```
 EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMLITUDE LOADING SPECTRUM
2024-T3  SHEET
2.2374E-09      0.70    3.3386 6.2126E-9      0.00     2.9783
   116.00       36.0      53.0       2.0       2.3       0.99     -0.99
   10.426      -.366     0.892   10700.0     0.022      1.000       1.0       1.0
   0.050       8.180     0.050     0.188     .0000      0.000     0.000     0.000
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.4660E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
    0.188     0.1250      8.18      9.82   0.00000     .00000    99.900  50. 1.00
   0.0000     0.1250      0.00      1.64   0.00000     .00000   0.00000    .00000
   0.000      0.0000
   0    00    1     1     0  100 1030 1050
    0.000      0.000     0.000     0.000     0.000      0.000     0.000     0.000
    120.0       25.0     6000.         1
```

TABLE 3.1.2-6. EXAMPLE 1, METHOD 2, RUN 3 OUTPUT FILE

```
     *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM    D A M G R O  *****

  EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM

     * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

 NO. OF SITES TO BE ANALYZED :    CRACK GROWTH =     1;   CRACK INITIATION =    1
  CORRESPONDING DAMAGE CODES :    CRACK GROWTH = 1030;   CRACK INITIATION = 1050

 LOAD INTERACTION :        NONE

 MATERIAL :    2024-T3   SHEET
     WALKER EQ. CONST. (+R) :   C = 0.224E-08,   M =0.700,   N =3.339
     WALKER EQ. CONST. (-R) :   C = 0.621E-08,   M =0.000,   N =2.978
     MAX.  K  FOR DC/DN THRESHOLD = 2.000
     RETARDATION SHUT-OFF RATIO = 2.300
     +R CUT-OFF = 0.9900,    -R CUT-OFF = -0.9900
     YIELD STRENGTH :  53.000
     ELASTIC MODULUS = 0.1070E+05
     PL. STRESS FRACT. TOUGHNESS =   116.00
     PL. STRAIN FRACT. TOUGHNESS = 36.00
     DAMAGE INDEX FOR CRACK INITIATION =   0.892
     NEUBER MATERIAL CONST. = 0.022
     CRACK INITIATION EQ. CONST. :  SF = 10.426,  M =-.366
     STRESS SEVERITY FACTOR PARAMETERS :
       ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

 SPECIFIED DAMAGE CONDITIONS :
     INITIAL CRACK LENGTH OF CRACK NO. 1 :     0.05000
     FINAL CRACK LENGTH OF CRACK NO. 1 :       8.18000
     INITIAL CRACK DEPTH OF CRACK NO. 1 :      0.05000
     FINAL CRACK DEPTH OF CRACK NO. 1 :        0.18800
     INITIAL CRACK LENGTH OF CRACK NO. 2       0.00000
     FINAL CRACK LENGTH OF CRACK NO. 2 :       0.00000
     INITIAL CRACK DEPTH OF CRACK NO. 2 :      0.00000
     FINAL CRACK DEPTH OF CRACK NO  2 :        0.00000
     PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY
       APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
        AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
       APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
        AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
     PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :
         DMG1 = .466E+00, DMGOL1 = .000E+00,  DELDG1 = .000E+00
         DMG2 = .000E+00, DMGOL2 = .000E+00,  DELDG2 = .000E+00
```

TABLE 3.1.2-6. EXAMPLE 1, METHOD 2, RUN 3 OUTPUT FILE (CON'T.)

```
COMPONENT GEOMETRY :
    THICKNESS OF PLATE :                                        0.18000
    RADIUS OF MID. HOLE :                                       0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :              99.99999
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :                8.18000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :                9.82000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :                    0.00000,  0.00000
    RADIUS OF THE R.H.S. HOLE :                                 0.00000
    DISTANCE BETWEEN MID. AND R.H.S. HOLES :                    0.00000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :                  0.00000,  0.00000
    RADIUS OF THE L.H.S. HOLE :                                 0.12500
    DISTANCE BETWEEN MID. AND L.H.S. HOLES :                    1.64000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :                  0.00000,  0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS            20.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION                  1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS :                   0.0000
    FAYING SURFACE FRICTION STRESS :                            0.0000

STRESS SPECTRUM :
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                      100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                       2000.000
    TOTAL NO. OF FLIGHTS IN ONE BLOCK :                       120.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME                       25.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :             6000.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM                        17.000
    NO. OF STRESS LAYERS IN ONE BLOCK                            2
```

TABLE 3.1.2-6. EXAMPLE 1, METHOD 2, RUN 3 OUTPUT FILE (CONCLUDED)

```
STRESS LAYERS IN ONE BLOCK :
    STEP SIGMA-MAX  SIGMA-MIN   CYCLES        STEP SIGMA-MAX  SIGMA-MIN   CYCLES
      1     17.000       1.700 1000.000         2     17.000       1.700 1000.000



        *******   D A M A G E   G R O W T H   H I S T O R Y   *******

BLOCK       C1        C2     KMAX-C1   KMAX-C2    DC1/DF     DC2/DF    INITIA1    INITIA2
            A1        A2     KMAX-A1   KMAX-A2    DA1/DF     DA2/DF       KN1        KN2
  0.0  0.05000   0.00000    19.898     0.000   .000E+00   .000E+00   .546E+00   .000E+00
       0.05000   0.00000    24.939     0.000   .000E+00   .000E+00   .497E+01   .000E+00

STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :
    CYC=   157.0,     STEP =     2,     BLOCK =     1,     CRACK DEPTH = 0.18954
CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS  0.1880  INCHES

  1.0  0.33032   0.00000    34.706     0.000   .234E-02   .000E+00   .744E+00   .000E+00
       0.18800   0.00000     0.000     0.000   .115E-02   .000E+00   .526E+01   .000E+00


CRACK INITIATION FOR LOCATION  1  OCCURS AT :
    CYC =1000.000,    STEP =    1,     BLOCK =    3
  2.0  0.96141   0.00000    39.187     0.000   .526E-02   .000E+00   .890E+00   .000E+00
       0.18800   0.00000     0.000     0.000   .000E+00   .000E+00   .587E+01   .000E+00

    CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
          C1 = 1.36451,    A1 = 0.18800,    C2 = 0.00000,    A2 = 0.00000


    RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION
        DMG1 = .890E+00, DMGOL1 =.000E+00,  DELOG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.1.2-7. EXAMPLE 1, METHOD 2, RUN 4 INPUT FILE

```
 EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMLITUDE LOADING SPECTRUM
2024-T3  SHEET
2.2374E-09     0.70     3.3386 6.2126E-9     0.00     2.9783
   116.00      36.0      53.0       2.0       2.3      0.99     -0.99
  10.426      -.366      0.892  10700.0     0.022     1.000      1.0       1.0
  1.364       8.180      0.188     0.188     .0500     8.180     0.050     0.188
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
    0.188     0.1250      8.18      9.82   0.00000    .00000    99.900  50. 1.00
   0.0000     0.1250      0.00      1.64   0.00000    .00000   0.00000    .00000
   0.000      0.0000
   0   00     2    0     0  100 1050 0000
    0.000      0.000     0.000     0.000     0.000     0.000     0.000     0.000
    120.0       25.0     6000.         1
```

TABLE 3.1.2-8. EXAMPLE 1, METHOD 2, RUN 4 OUTPUT FILE

```
      *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM   D A M G R O  *****

  EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM

     * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED :   CRACK GROWTH =    2;  CRACK INITIATION =     0
 CORRESPONDING DAMAGE CODES :   CRACK GROWTH = 1050;  CRACK INITIATION =     0

LOAD INTERACTION :       NONE

MATERIAL :   2024-T3  SHEET
    WALKER EQ. CONST. (+R) :  C = 0.224E-08,  M =0.700,  N =3.339
    WALKER EQ. CONST. (-R) :  C = 0.621E-08,  M =0.000,  N =2.978
    MAX.  K  FOR DC/DN THRESHOLD = 2.000
    RETARDATION SHUT-OFF RATIO = 2.300
    +R CUT-OFF = 0.9900,   -R CUT-OFF = -0.9900
    YIELD STRENGTH :  53.000
    ELASTIC MODULUS = 0.1070E+05
    PL. STRESS FRACT. TOUGHNESS =  116.00
    PL. STRAIN FRACT. TOUGHNESS = 36.00
    DAMAGE INDEX FOR CRACK INITIATION =  0.892
    NEUBER MATERIAL CONST. = 0.022
    CRACK INITIATION EQ. CONST.  :  SF  = 10.426,   M =-.366
    STRESS SEVERITY FACTOR PARAMETERS :
      ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :
    INITIAL CRACK LENGTH OF CRACK NO. 1 :    1.36400
    FINAL CRACK LENGTH OF CRACK NO. 1 :      8.18000
    INITIAL CRACK DEPTH OF CRACK NO. 1 :     0.18800
    FINAL CRACK DEPTH OF CRACK NO. 1 :       0.18800
    INITIAL CRACK LENGTH OF CRACK NO. 2 :    0.05000
    FINAL CRACK LENGTH OF CRACK NO. 2 :      8.18000
    INITIAL CRACK DEPTH OF CRACK NO. 2 :     0.05000
    FINAL CRACK DEPTH OF CRACK NO. 2 :       0.18800
    PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,   CKOL1 = .000E+00,    AOL1 = .000E+00,    COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,   CKOL2 = .000E+00,    AOL2 = .000E+00,    COL2 = .000E+00
    PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY
        DMG1 = .000E+00, DMGOL1 =.000E+00,   DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,   DELDG2 =.000E+00
```

TABLE 3.1.2-8. EXAMPLE 1, METHOD 2, RUN 4 OUTPUT FILE (CON'T.)

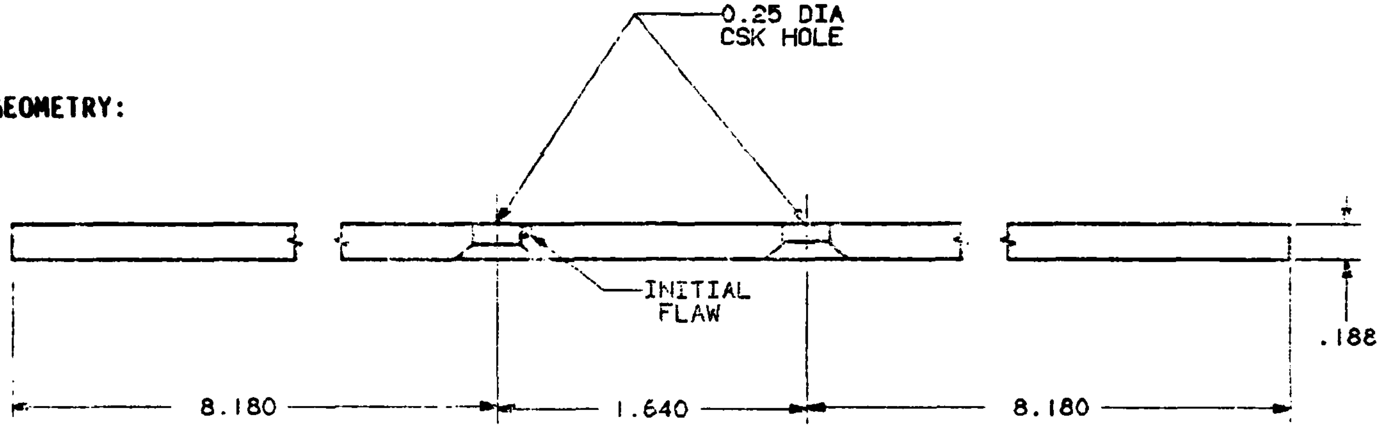
```
COMPONENT GEOMETRY :
    THICKNESS OF PLATE :                                    0.18800
    RADIUS OF MID. HOLE :                                   0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :          99.89999
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :            8.18000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :            9.82000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :                0.00000,   0.00000
    RADIUS OF THE R.H.S. HOLE :                             0.00000
    DISTANCE BETWEEN MID. AND R.H.S. HOLES :                0.00000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :              0.00000,   0.00000
    RADIUS OF THE L.H.S. HOLE :                             0.12500
    DISTANCE BETWEEN MID. AND L.H.S. HOLES :                1.64000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :              0.00000,   0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :      20.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION :            1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS :               0.0000
    FAYING SURFACE FRICTION STRESS :                        0.0000

STRESS SPECTRUM :
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                  100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                     2000.000
    TOTAL NO. OF FLIGHTS IN ONE BLOCK :                     120.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME :                   25.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :           6000.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM :                    17.000
    NO. OF STRESS LAYERS IN ONE BLOCK                         2
```

TABLE 3.1.2-8. EXAMPLE 1, METHOD 2, RUN 4 OUTPUT FILE (CONCLUDED)

```
STRESS LAYERS IN ONE BLOCK :
    STEP SIGMA-MAX  SIGMA-MIN   CYCLES        STEP SIGMA-MAX  SIGMA-MIN   CYCLES
       1    17.000      1.700 1000.000           2    17.000      1.700 1000.000

UNSTABLE BREAK-THROUGH OF CRACK NO. 2 OCCURS AT :
  CYC =    0.0,  STEP =    1,  BLOCK =    1,  DEPTH = 0.05000,  AKMAXS= 37.79



        *******  D A M A G E   G R O W T H   H I S T O R Y   *******

BLOCK        C1        C2    KMAX-C1  KMAX-C2    DC1/DF     DC2/DF   INITIA1    INITIA2
             A1        A2    KMAX-A1  KMAX-A2    DA1/DF     DA2/DF       KN1        KN2
  0.0   1.36400   0.05000    41.432   30.154  .000E+00   .000E+00  .000E+00  .000E+00
        0.18800   0.05000     0.000   37.792  .000E+00   .000E+00  .000E+00  .000E+00
  1.0   2.61890   1.23327    56.095   56.847  .105E-01   .986E-02  .000E+00  .000E+00
        0.18800   0.18800     0.000    0.000  .000E+00   .115E-02  .000E+00  .000E+00

UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:
    CYC =   15.0,  STEP =   2,  BLOCK =   2,  CRACK LENGTH = 4.57208,  CKMAXS=116.06
THE OTHER CRACK LENGTH = 3.18957
TERMINATE DAMAGE COMPUTATION

UNSTABLE GROWTH OF CRACK NO. 2 OCCURS AT:
    CYC =    4.0,  STEP =   2,  BLOCK =   2,  CRACK LENGTH = 3.25368,  CKMAXS=117.03
THE OTHER CRACK LENGTH = 4.57208
TERMINATE DAMAGE COMPUTATION


    RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
        DMG1 = .000E+00, DMGOL1 =.000E+00,  DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

EXAMPLE 2: SKIN SECTION SUBJECTED TO RANDOMIZED LOADING SPECTRUM

GEOMETRY:



MATERIAL:

2024-T3 SHEET

LOADING SPECTRUM:

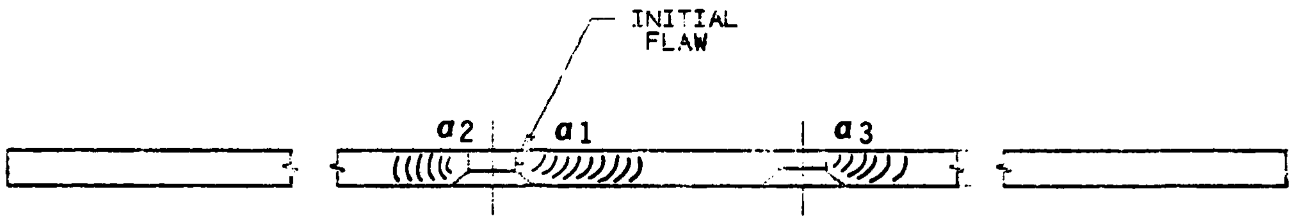
RANDOMIZED BLOCK LOADING

σ_{max} = 35.75 KSI

REF. PAGES 67 THROUGH 90

TABLE 3.2.1. EXAMPLE 2, METHOD 1 SUMMARY TABLE

REF. PAGES 68 THROUGH 76



a 1 (IN)	a 2 (IN)	a 3 (IN)	LIFE (BLOCK, LAYER, CYCLES)	ROUTINE GROWTH	RUN NO.
.050	0	.005	0	K1010	1
.065	0	.005	1, 0, 0	K1010	1
.091	0	.005	2, 0, 0	K1010	1
.126	0	.005	3, 0, 0	K1010	1
.164	0	.005	4, 0, 0	K1010	1
.208	0	.005	5, 0, 0	K1010	1
.258	0	.005	6, 0, 0	K1010	1
.316	0	.005	7, 0, 0	K1010	1
.384	0	.005	8, 0, 0	K1010	1
.466	0	.005	9, 0, 0	K1010	1
.566	0	.005	10, 0, 0	K1010	1
.693	0	.005	11, 0, 0	K1010	1
.859	0	.005	12, 0, 0	K1010	1
1.094	0	.005	13, 0, 0	K1010	1
1.39	0	.023	13,119,32	K1010	1
	0	.622	14, 0 ,32	K1030	2
	0	2.16	15, 0 ,32	K1030	2
	0	3.6507	15, 98,38	K1030	2

NO. OF CYCLES TO FAILURE = 111,955 CYCLES

TABLE 3.2.1-1. EXAMPLE 2, METHOD 1, RUN 1 INPUT FILE

```
EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
2024-T3  SHEET
2.2374E-09       0.70     3.3386 6.2126E-9      0.00     2.9783
   116.00        36.0       53.0       2.0       2.3       0.99      -0.99
   10.426       -.366      0.887   10700.0     0.022      1.000        1.0        1.0
   0.050        1.390      0.050     0.188     .0000      0.000      0.000      0.000
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
    0.188      0.1250       9.82      8.18   0.00000    .00000     99.900  50. 1.00
   0.1250      0.0000       1.64      0.00   0.00000    .00000    0.00000    .00000
   0.000       0.0000
   0    00     1    0     1  100 1010 0000
    0.000       0.000      0.000     0.000     0.000      0.000      0.000      0.000
    120.0        25.0      6000.         1
```

TABLE 3.2.1-2. EXAMPLE 2, METHOD 1, RUN 1 OUTPUT FILE

```
      *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM   D A M G R O  *****

 EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING  SPECTRUM

    * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED :   CRACK GROWTH =    1;  CRACK INITIATION =    0
 CORRESPONDING DAMAGE CODES :   CRACK GROWTH = 1010;  CRACK INITIATION =    0

LOAD INTERACTION :      GENERALIZED WILLENBORG ET AL--CHANG MODEL

MATERIAL :   2024-T3  SHEET
    WALKER EQ. CONST. (+R) :  C = 0.224E-08,  M =0.700,  N =3.339
    WALKER EQ. CONST. (-R) :  C = 0.621E-08,  M =0.000,  N =2.978
    MAX.  K  FOR DC/DN THRESHOLD = 2.000
    RETARDATION SHUT-OFF RATIO = 2.300
    +R CUT-OFF = 0.9900,   -R CUT-OFF = -0.9900
    YIELD STRENGTH :  53.000
    ELASTIC MODULUS = 0.1070E+05
    PL. STRESS FRACT. TOUGHNESS =  116.00
    PL. STRAIN FRACT. TOUGHNESS = 36.00
    DAMAGE INDEX FOR CRACK INITIATION =  0.887
    NEUBER MATERIAL CONST. = 0.022
    CRACK INITIATION EQ. CONST. :  SF = 10.426,  M =-.366
    STRESS SEVERITY FACTOR PARAMETERS :
      ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :
    INITIAL CRACK LENGTH OF CRACK NO. 1 :    0.05000
    FINAL CRACK LENGTH OF CRACK NO. 1 :      1.39000
    INITIAL CRACK DEPTH OF CRACK NO. 1 :     0.05000
    FINAL CRACK DEPTH OF CRACK NO. 1 :       0.18800
    INITIAL CRACK LENGTH OF CRACK NO. 2 :    0.00000
    FINAL CRACK LENGTH OF CRACK NO. 2 :      0.00000
    INITIAL CRACK DEPTH OF CRACK NO. 2 :     0.00000
    FINAL CRACK DEPTH OF CRACK NO. 2 :       0.00000
    PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :
        DMG1 = .000E+00, DMGOL1 =.000E+00,  DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.2.1-2. EXAMPLE 2, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

```
COMPONENT GEOMETRY :
    THICKNESS OF PLATE :                                          0.18800
    RADIUS OF MID. HOLE :                                         0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :                99.89999
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :                  9.82000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :                  8.18000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :                      0.00000,   0.00000
    RADIUS OF THE R.H.S. HOLE :                                   0.12500
    DISTANCE BETWEEN MID. AND R.H.S. HOLES :                      1.64000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :                    0.00000,   0.00000
    RADIUS OF THE L.H.S. HOLE :                                   0.00000
    DISTANCE BETWEEN MID. AND L.H.S. HOLES :                      0.00000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :                    0.00000,   0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :            50.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION :                  1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS :                     0.0000
    FAYING SURFACE FRICTION STRESS :                              0.0000

STRESS SPECTRUM :
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                        100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                           7416.500
    TOTAL NO. OF FLIGHTS IN ONE BLOCK :                           120.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME :                         25.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :                 6000.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM :                          35.750
    NO. OF STRESS LAYERS IN ONE BLOCK                             204
```

TABLE 3.2.1-2. EXAMPLE 2, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

STRESS LAYERS IN ONE BLOCK :

STEP	SIGMA-MAX	SIGMA-MIN	CYCLES	STEP	SIGMA-MAX	SIGMA-MIN	CYCLES
1	33.609	-23.523	1.000	2	35.750	-23.244	4.000
3	16.447	-2.462	1.000	4	32.181	-3.217	1.000
5	35.750	-3.579	1.000	6	23.595	-1.179	1.000
7	27.888	-1.396	1.000	8	30.030	-1.500	1.000
9	33.609	-1.676	4.000	10	35.750	-1.790	2.000
11	28.602	0.000	4.000	12	29.316	0.000	1.000
13	30.030	0.000	3.000	14	32.181	0.000	12.000
15	33.609	0.000	9.000	16	35.750	0.000	1.500
17	16.447	0.817	2.500	18	17.161	0.859	2.000
19	17.875	0.889	5.000	20	18.589	0.931	3.000
21	19.313	0.962	1.000	22	20.027	1.004	1.000
23	20.740	1.035	1.000	24	21.454	1.076	6.000
25	22.168	1.107	2.000	26	22.882	1.148	1.000
27	23.595	1.179	11.000	28	25.747	1.283	6.000
29	26.461	1.324	6.000	30	27.175	1.355	2.000
31	28.602	1.427	4.000	32	29.316	1.469	3.000
33	30.030	1.500	2.000	34	31.467	1.572	1.000
35	32.181	1.614	18.000	36	33.609	1.676	11.000
37	35.750	1.790	0.500	38	10.727	1.076	1.000
39	13.582	1.355	2.000	40	14.306	1.427	1.000
41	21.454	2.141	12.000	42	22.168	2.214	4.000
43	22.882	2.286	9.000	44	23.595	2.358	21.000
45	24.309	2.431	4.000	46	25.033	2.503	1.000
47	25.747	2.576	18.000	48	26.461	2.648	7.000
49	27.175	2.721	4.000	50	27.888	2.793	1.000
51	28.602	2.865	24.500	52	29.316	2.928	6.000
53	30.030	3.000	32.000	54	31.467	3.145	2.000
55	32.181	3.217	3.000	56	33.609	3.362	1.000
57	14.306	2.141	1.000	58	16.447	2.462	10.000
59	17.161	2.576	4.000	60	17.875	2.679	7.000
61	19.313	2.896	4.000	62	20.027	3.000	14.000
63	20.740	3.113	5.000	64	21.454	3.217	3.000
65	22.168	3.320	4.000	66	22.882	3.434	4.000
67	23.595	3.538	18.000	68	24.309	3.652	1.000
69	25.033	3.755	2.000	70	25.747	3.858	11.000
71	26.461	3.972	10.000	72	27.175	4.075	8.000
73	27.888	4.179	1.000	74	28.602	4.293	11.500
75	29.316	4.396	1.000	76	30.030	4.510	7.000
77	33.609	5.038	1.000	78	5.720	1.148	5.000
79	7.148	1.427	1.000	80	12.868	2.576	1.000
81	13.582	2.721	2.000	82	14.306	2.865	4.000
83	15.020	3.000	2.000	84	17.875	3.579	12.000
85	18.589	3.714	8.000	86	19.313	3.858	6.000
87	20.027	4.003	22.000	88	20.740	4.148	17.000
89	21.454	4.293	58.000	90	22.168	4.438	24.000
91	22.882	4.572	11.000	92	23.595	4.717	38.000
93	24.309	4.862	6.000	94	25.033	5.007	5.000
95	25.747	5.152	28.000	96	28.602	5.720	20.000
97	29.316	5.865	4.000	98	30.030	6.010	9.000
99	32.181	6.434	10.000	100	33.609	6.724	1.000
101	10.727	2.679	2.000	102	12.155	3.041	2.000
103	12.868	3.217	2.000	104	13.582	3.393	1.000
105	14.306	3.579	2.000	106	15.020	3.755	3.000
107	16.447	4.107	8.500	108	17.161	4.293	27.000
109	17.875	4.469	134.000	110	18.589	4.645	6.000
111	19.313	4.831	13.000	112	20.027	5.007	111.000
113	21.454	5.358	1.000	114	22.168	5.544	3.000
115	22.882	5.720	1.000	116	23.595	5.896	89.000

TABLE 3.2.1-2. EXAMPLE 2, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

STRESS LAYERS IN ONE BLOCK :

STEP	SIGMA-MAX	SIGMA-MIN	CYCLES	STEP	SIGMA-MAX	SIGMA-MIN	CYCLES
117	24.309	6.083	20.000	118	25.033	6.258	3.000
119	25.747	6.434	61.000	120	26.461	6.610	17.000
121	27.175	6.796	13.000	122	28.602	7.148	5.000
123	30.030	7.510	3.000	124	4.293	1.283	1.000
125	5.007	1.500	2.000	126	12.155	[illegible]	1.000
127	12.868	3.858	5.000	128	13.582	4.075	[illegible]
129	15.020	4.510	23.000	130	15.734	4.717	17.000
131	16.447	4.934	111.000	132	17.161	5.152	4.000
133	17.875	5.358	1.000	134	18.589	5.576	6.000
135	19.313	5.793	1.000	136	20.027	6.010	209.000
137	20.740	6.217	43.000	138	21.454	6.434	134.000
139	22.168	6.651	13.000	140	22.882	6.869	[illegible]
141	24.309	7.293	5.000	142	11.441	4.003	7.000
143	12.155	4.251	49.000	144	12.868	4.510	6.000
145	13.582	4.758	10.000	146	14.306	5.007	258.000
147	15.020	5.255	3.000	148	16.447	5.751	14.000
149	17.161	6.010	8.000	150	17.875	6.258	[illegible]
151	18.589	6.506	1.000	152	19.313	6.755	65.000
153	20.740	7.262	11.000	154	7.862	3.145	1.000
155	10.727	4.293	94.000	156	12.155	4.862	19.000
157	12.868	5.152	434.000	158	13.582	5.431	19.000
159	14.306	5.720	1.000	160	15.020	6.010	19.000
161	15.734	6.289	2.000	162	16.447	6.579	494.000
163	17.161	6.869	92.000	164	18.589	7.437	4.000
165	19.313	7.727	19.000	166	6.434	2.896	2.000
167	7.148	3.217	19.000	168	9.300	4.179	236.000
169	10.727	4.831	534.000	170	12.155	5.472	1.000
171	12.868	5.793	54.000	172	13.582	6.114	5.000
173	14.306	6.434	716.000	174	15.020	6.755	130.000
175	16.447	7.396	11.000	176	17.161	7.727	36.000
177	7.862	3.931	8.000	178	11.441	5.720	5.000
179	12.155	6.083	31.000	180	12.868	6.434	363.000
181	13.582	6.796	93.000	182	15.020	7.510	63.000
183	7.862	4.324	3.000	184	10.727	5.896	37.000
185	12.155	6.682	278.000	186	12.868	7.076	[illegible]
187	13.582	7.469	38.000	188	7.148	4.293	3.000
189	11.441	6.869	1.000	190	7.148	4.645	7.000
191	7.862	5.110	67.000	192	6.434	4.510	12.000
193	7.148	5.007	212.500	194	5.720	4.293	2.000
195	7.862	5.896	1.000	196	5.007	4.251	1.000
197	5.720	4.862	1.000	198	7.148	6.083	17.000
199	7.862	6.682	293.000	200	7.148	6.434	7.000
201	5.007	4.758	22.000	202	6.434	6.114	4.000
203	7.148	6.796	52.000	204	7.862	7.469	2.000

TABLE 3.2.1-2. EXAMPLE 2, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

******* D A M A G E   G R O W T H   H I S T O R Y *******

BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
0.0	0.05000	0.00000	20.192	0.000	.000E+00	.000E+00	.000E+00	.000E+00
	0.05000	0.00000	25.306	0.000	.000E+00	.000E+00	.000E+00	.000E+00
1.0	0.06587	0.00000	24.246	0.000	.132E-03	.000E+00	.000E+00	.000E+00
	0.08191	0.00000	27.526	0.000	.266E-03	.000E+00	.000E+00	.000E+00
2.0	0.09110	0.00000	27.624	0.000	.210E-03	.000E+00	.000E+00	.000E+00
	0.12312	0.00000	29.527	0.000	.343E-03	.000E+00	.000E+00	.000E+00
3.0	0.12659	0.00000	28.050	0.000	.296E-03	.000E+00	.000E+00	.000E+00
	0.17173	0.00000	28.167	0.000	.405E-03	.000E+00	.000E+00	.000E+00

STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :
CYC= 1.0, STEP = 77, BLOCK = 4, CRACK DEPTH = 0.18808
CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS 0.1880 INCHES

4.0	0.16422	0.00000	30.549	0.000	.314E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.136E-03	.000E+00	.000E+00	.000E+00
5.0	0.20819	0.00000	31.702	0.000	.366E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
6.0	0.25813	0.00000	33.030	0.000	.416E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
7.0	0.31610	0.00000	34.575	0.000	.483E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
8.0	0.38452	0.00000	36.379	0.000	.570E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
9.0	0.46651	0.00000	38.493	0.000	.683E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
10.0	0.56608	0.00000	40.982	0.000	.830E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
11.0	0.69343	0.00000	44.054	0.000	.106E-02	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
12.0	0.85973	0.00000	47.965	0.000	.139E-02	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
13.0	1.09410	0.00000	53.984	0.000	.195E-02	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00

TABLE 3.2.1-2. EXAMPLE 2, METHOD 1, RUN 1 OUTPUT FILE (CONCLUDED)

```
UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:
    CYC =   32.0,   STEP =119,   BLOCK = 14,   CRACK LENGTH = 1.38295,   CKMAXS=117.96
THE OTHER CRACK LENGTH = 0.00000
TERMINATE DAMAGE COMPUTATION

    RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
      APAOL1 = .202E+00, APCOL1 = .166E+01, RYAOL1 = .137E-01, RYCOL1 = .295E+00
       AKOL1 = .269E+02,  CKOL1 = .722E+02,    AOL1 = .188E+00,    COL1 = .137E+01
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,    AOL2 = .000E+00,    COL2 = .000E+00
    RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
        DMG1 = .000E+00, DMGOL1 =.000E+00,  DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.2.1-3. EXAMPLE 2, METHOD 1, RUN 2 INPUT FILE

```
EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
2024-T3  SHEET
2.2374E-09        0.70      3.3386 6.2126E-9       0.00      2.9783
    116.00        36.0        53.0       2.0        2.3        0.99      -0.99
    10.426       -.366       0.887   10700.0      0.022       1.000        1.0        1.0
     0.230       8.180       0.188     0.188      .0000       0.000      0.000      0.000
0.1980E+000.2870E+000.1080E-010.5260E-010.2390E+020.3050E+020.1880E+000.2340E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
     0.188      0.1250        8.18      9.82    0.00000      .00000     99.900  50. 1.00
    0.0000      0.1250        0.00      1.64    0.00000      .00000    0.00000     .00000
    0.000       0.0000
    1   119     1    0     1   100 1030 0000
     0.000       0.000       0.000     0.000      0.000       0.000      0.000      0.000
     120.0        25.0       6000.         1
```

TABLE 3.2.1-4. EXAMPLE 2, METHOD 1, RUN 2 OUTPUT FILE

```
     *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM    D A M G R O  *****

 EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING  SPECTRUM

    * THIS ANALYSIS RESTARTS WITH THE STRESS SPECTRUM AT STEP 119 *

NO. OF SITES TO BE ANALYZED :    CRACK GROWTH =    1;  CRACK INITIATION =    0
 CORRESPONDING DAMAGE CODES :    CRACK GROWTH = 1030;  CRACK INITIATION =    0

LOAD INTERACTION :       GENERALIZED WILLENBORG ET AL--CHANG MODEL

MATERIAL :    2024-T3  SHEET
    WALKER EQ. CONST. (+R) :  C = 0.224E-08,  M =0.700,  N =3.339
    WALKER EQ. CONST. (-R) :  C = 0.621E-08,  M =0.000,  N =2.978
    MAX.  K  FOR DC/DN THRESHOLD = 2.000
    RETARDATION SHUT-OFF RATIO = 2.300
    +R CUT-OFF = 0.9900,   -R CUT-OFF = -0.9900
    YIELD STRENGTH :  53.000
    ELASTIC MODULUS = 0.1070E+05
    PL. STRESS FRACT. TOUGHNESS =  116.00
    PL. STRAIN FRACT. TOUGHNESS = 36.00
    DAMAGE INDEX FOR CRACK INITIATION =  0.887
    NEUBER MATERIAL CONST. = 0.022
    CRACK INITIATION EQ. CONST.  :  SF = 10.426,  M =-.366
    STRESS SEVERITY FACTOR PARAMETERS :
      ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :
    INITIAL CRACK LENGTH OF CRACK NO. 1 :    0.23000
    FINAL CRACK LENGTH OF CRACK NO. 1 :      8.18000
    INITIAL CRACK DEPTH OF CRACK NO. 1 :     0.18800
    FINAL CRACK DEPTH OF CRACK NO. 1 :       0.18800
    INITIAL CRACK LENGTH OF CRACK NO. 2 :    0.00000
    FINAL CRACK LENGTH OF CRACK NO. 2 :      0.00000
    INITIAL CRACK DEPTH OF CRACK NO. 2 :     0.00000
    FINAL CRACK DEPTH OF CRACK NO. 2 :       0.00000
    PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY
      APAOL1 = .198E+00, APCOL1 = .287E+00, RYAOL1 = .108E-01, RYCOL1 = .526E-01
       AKOL1 = .239E+02,  CKOL1 = .305E+02,   AOL1 = .188E+00,   COL1 = .234E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :
        DMG1 = .000E+00, DMGOL1 =.000E+00,  DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.2.1-4. EXAMPLE 2, METHOD 1, RUN 2 OUTPUT FILE (CON'T.)

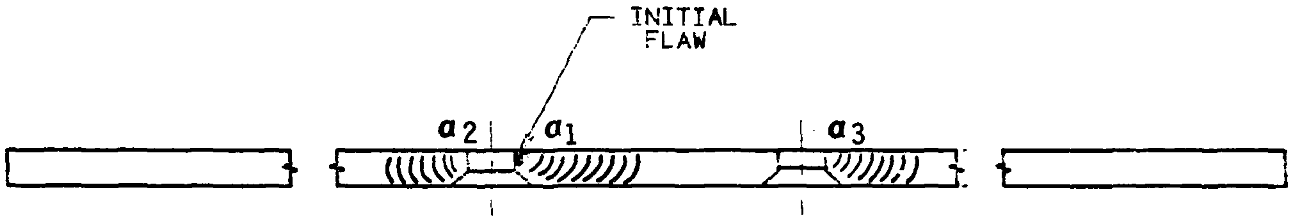
```
COMPONENT GEOMETRY :
    THICKNESS OF PLATE :                                   0.18800
    RADIUS OF MID. HOLE :                                  0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :         99.89999
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :           8.18000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :           9.82000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :               0.00000,   0.00000
    RADIUS OF THE R.H.S. HOLE :                            0.00000
    DISTANCE BETWEEN MID. AND R.H.S. HOLES :               0.00000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :             0.00000,   0.00000
    RADIUS OF THE L.H.S. HOLE :                            0.12500
    DISTANCE BETWEEN MID. AND L.H.S. HOLES :               1.64000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :             0.00000,   0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :     50.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION :           1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS :              0.0000
    FAYING SURFACE FRICTION STRESS :                       0.0000

STRESS SPECTRUM :
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                 100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                    7416.500
    TOTAL NO. OF FLIGHTS IN ONE BLOCK :                    120.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME :                  25.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :          6000.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM :                   35.750
    NO. OF STRESS LAYERS IN ONE BLOCK                      204
```

TABLE 3.2.1-4. EXAMPLE 2, METHOD 1, RUN 2 OUTPUT FILE (CONCLUDED)

```
        *******   D A M A G E   G R O W T H   H I S T O R Y   *******

BLOCK      C1        C2     KMAX-C1  KMAX-C2   DC1/DF     DC2/DF    INITIA1    INITIA2
           A1        A2     KMAX-A1  KMAX-A2   DA1/DF     DA2/DF      KN1        KN2
  0.0  0.23000   0.00000    68.666    0.000  .000E+00   .000E+00   .000E+00   .000E+00
       0.18800   0.00000     0.000    0.000  .000E+00   .000E+00   .000E+00   .000E+00
  1.0  0.62217   0.00000    78.573    0.000  .327E-02   .000E+00   .000E+00   .000E+00
       0.18800   0.00000     0.000    0.000  .000E+00   .000E+00   .000E+00   .000E+00
  2.0  2.16138   0.00000    96.070    0.000  .128E-01   .000E+00   .000E+00   .000E+00
       0.18800   0.00000     0.000    0.000  .000E+00   .000E+00   .000E+00   .000E+00

UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:
    CYC =    6.0,  STEP = 98,  BLOCK =   3,  CRACK LENGTH = 3.65077,  CKMAXS=116.20
THE OTHER CRACK LENGTH = 0.00000
TERMINATE DAMAGE COMPUTATION


    RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
      APAOL1 = .198E+00, APCOL1 = .415E+01, RYAOL1 = .108E-01, RYCOL1 = .535E+00
       AKOL1 = .239E+02,  CKOL1 = .972E+02,   AOL1 = .188E+00,   COL1 = .361E+01
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION
        DMG1 = .000E+00, DMGOL1 =.000E+00,   DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,   DELDG2 =.000E+00
```

TABLE 3.2.2. EXAMPLE 2, METHOD 2 SUMMARY TABLE

REF. PAGES 78 THROUGH 90



a 1 (IN)	a 2 (IN)	a 3 (IN)	LIFE (BLOCK, LAYER, CYCLES)	ROUTINES GROWTH	ROUTINES INITIATION	RUN NO.
.050	0	0	0	K1010	S1010	1
.065	0	0	1, 0, 0	K1010	S1010	1
.091	0	0	2, 0, 0	K1010	S1010	1
.126	0	0	3, 0, 0	K1010	S1010	1
.164	0	0	4, 0, 0	K1010	S1010	1
.208	0	0	5, 0, 0	K1010	S1010	1
.258	0	0	6, 0, 0	K1010	S1010	1
.316	0	0	7, 0, 0	K1010	S1010	1
.384	0	0	8, 0, 0	K1010	S1010	1
.466	0	0	9, 0, 0	K1010	S1010	1
.566	0	0	10, 0, 0	K1010	S1010	1
.693	0	0	11, 0, 0	K1010	S1010	1
.859	0	0	12, 0, 0	K1010	S1010	1
.901	.050	0	12, 36,11	K1010	S1010	1
1.218	.45	0	13, 0,22	K1040	S1030	2
1.39	.532	0	13, 34,23	K1040	S1030	2
	1.044	.050	13, 96,40	K1030	S1050	3
	2.205	1.229	14, 0,40	K1050	-	4

NO. OF CYCLES TO SECONDARY CRACK INITIATION = 89,134 CYCLES
NO. OF CYCLES TO FAILURE = 103,871 CYCLES

TABLE 3.2.2-1. EXAMPLE 2, METHOD 2, RUN 1 INPUT FILE

```
 EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
2024-T3  SHEET
2.2374E 09       0.70      3.3386 6.2126E 9      0.00      2.9783
   116.00        36.0       53.0        2.0       2.3       0.99      -0.99
   10.426       -.366      0.887    10700.0     0.022     1.000        1.0        1.0
   0.050        1.390      0.050      0.188     .0000     0.000      0.000      0.000
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
    0.188      0.1250       9.82       8.18   0.00000    .00000     99.900  50. 1.00
   0.1250      0.0000       1.64       0.00   0.00000    .00000    0.00000    .00000
   0.000       0.0000
   0    00     1     2     1  100 1010 1010
    0.000       0.000      0.000      0.000     0.000     0.000      0.000      0.000
    120.0        25.0      6000.          1
```

TABLE 3.2.2-2. EXAMPLE 2, METHOD 2, RUN 1 OUTPUT FILE

```
      *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM   D A M G R O  *****

   EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING  SPECTRUM

      * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED :   CRACK GROWTH =    1;  CRACK INITIATION =    2
 CORRESPONDING DAMAGE CODES :   CRACK GROWTH = 1010;  CRACK INITIATION = 1010

LOAD INTERACTION :      GENERALIZED WILLENBORG ET AL--CHANG MODEL

MATERIAL :   2024-T3  SHEET
    WALKER EQ. CONST. (+R) :  C = 0.224E-08,  M =0.700,  N =3.339
    WALKER EQ. CONST. (-R) :  C = 0.621E-08,  M =0.000,  N =2.978
    MAX.  K  FOR DC/DN THRESHOLD = 2.000
    RETARDATION SHUT-OFF RATIO = 2.300
    +R CUT-OFF = 0.9900,    -R CUT-OFF = -0.9900
    YIELD STRENGTH :  53.000
    ELASTIC MODULUS = 0.1070E+05
    PL. STRESS FRACT. TOUGHNESS =  116.00
    PL. STRAIN FRACT. TOUGHNESS = 36.00
    DAMAGE INDEX FOR CRACK INITIATION =   0.887
    NEUBER MATERIAL CONST. = 0.022
    CRACK INITIATION EQ. CONST. :  SF = 10.426,  M =-.366
    STRESS SEVERITY FACTOR PARAMETERS :
      ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :
    INITIAL CRACK LENGTH OF CRACK NO. 1 :    0.05000
    FINAL CRACK LENGTH OF CRACK NO. 1 :      1.39000
    INITIAL CRACK DEPTH OF CRACK NO. 1 :     0.05000
    FINAL CRACK DEPTH OF CRACK NO. 1 :       0.18800
    INITIAL CRACK LENGTH OF CRACK NO. 2 :    0.00000
    FINAL CRACK LENGTH OF CRACK NO. 2 :      0.00000
    INITIAL CRACK DEPTH OF CRACK NO. 2 :     0.00000
    FINAL CRACK DEPTH OF CRACK NO. 2 :       0.00000
    PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :
        DMG1 = .000E+00, DMGOL1 =.000E+00,  DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.2.2-2. EXAMPLE 2, METHOD 2, RUN 1 OUTPUT FILE (CON'T.)

```
COMPONENT GEOMETRY :
    THICKNESS OF PLATE :                                    0.18800
    RADIUS OF MID. HOLE :                                   0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :          99.89999
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :            9.82000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :            8.18000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :                0.00000,   0.00000
    RADIUS OF THE R.H.S. HOLE :                             0.12500
    DISTANCE BETWEEN MID. AND R.H.S. HOLES :                1.64000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :              0.00000,   0.00000
    RADIUS OF THE L.H.S. HOLE :                             0.00000
    DISTANCE BETWEEN MID. AND L.H.S. HOLES :                0.00000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :              0.00000,   0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :      50.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION :            1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS :               0.0000
    FAYING SURFACE FRICTION STRESS :                        0.0000

STRESS SPECTRUM :
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                  100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                     7416.500
    TOTAL NO. OF FLIGHTS IN ONE BLOCK :                     120.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME :                   25.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :           6000.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM :                    35.750
    NO. OF STRESS LAYERS IN ONE BLOCK                       204
```

TABLE 3.2.2-2. EXAMPLE 2, METHOD 2, RUN 1 OUTPUT FILE (CON'T.)

******* D A M A G E G R O W T H H I S T O R Y *******

BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
0.0	0.05000	0.00000	20.192	0.000	.000E+00	.000E+00	.143E-03	.106E-03
	0.05000	0.00000	25.306	0.000	.000E+00	.000E+00	.278E+01	.263E+01
1.0	0.06587	0.00000	24.246	0.000	.132E-03	.000E+00	.293E-01	.209E-01
	0.08191	0.00000	27.526	0.000	.266E-03	.000E+00	.283E+01	.263E+01
2.0	0.09110	0.00000	27.624	0.000	.210E-03	.000E+00	.618E-01	.418E-01
	0.12312	0.00000	29.527	0.000	.343E-03	.000E+00	.290E+01	.263E+01
3.0	0.12659	0.00000	28.050	0.000	.296E-03	.000E+00	.980E-01	.626E-01
	0.17173	0.00000	28.167	0.000	.405E-03	.000E+00	.273E+01	.263E+01

STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :
CYC= 1.0, STEP = 77, BLOCK = 4, CRACK DEPTH = 0.18808
CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS 0.1880 INCHES

BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
4.0	0.16422	0.00000	30.549	0.000	.314E-03	.000E+00	.126E+00	.835E-01
	0.18800	0.00000	0.000	0.000	.136E-03	.000E+00	.282E+01	.263E+01
5.0	0.20819	0.00000	31.702	0.000	.366E-03	.000E+00	.159E+00	.104E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.292E+01	.263E+01
6.0	0.25813	0.00000	33.030	0.000	.416E-03	.000E+00	.199E+00	.125E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.303E+01	.263E+01
7.0	0.31610	0.00000	34.575	0.000	.483E-03	.000E+00	.248E+00	.146E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.315E+01	.263E+01
8.0	0.38452	0.00000	36.379	0.000	.570E-03	.000E+00	.309E+00	.167E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.328E+01	.263E+01
9.0	0.46651	0.00000	38.493	0.000	.683E-03	.000E+00	.387E+00	.188E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.344E+01	.263E+01
10.0	0.56608	0.00000	40.982	0.000	.830E-03	.000E+00	.488E+00	.207E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.361E+01	.263E+01
11.0	0.69343	0.00000	44.054	0.000	.106E-02	.000E+00	.622E+00	.229E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.383E+01	.263E+01
12.0	0.85973	0.00000	47.965	0.000	.139E-02	.000E+00	.809E+00	.256E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.409E+01	.263E+01

TABLE 3.2.2-2. EXAMPLE 2, METHOD 2, RUN 1 OUTPUT FILE (CONCLUDED)

```
CRACK INITIATION FOR LOCATION  1  OCCURS AT :
    CYC =  11.000,    STEP =  36,    BLOCK =  13

    CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
          C1 = 0.90143,    A1 = 0.18800,    C2 = 0.00000,    A2 = 0.00000


    RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
      APAOL1 = .202E+00, APCOL1 = .101E+01, RYAOL1 = .137E-01, RYCOL1 = .133E+00
       AKOL1 = .269E+02,  CKOL1 = .485E+02,   AOL1 = .188E+00,   COL1 = .880E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
        DMG1 = .879E+00, DMGOL1 =.970E-03,  DELDG1 =.000E+00
        DMG2 = .257E+00, DMGOL2 =.105E-03,  DELDG2 =.000E+00
```

TABLE 3.2.2-3. EXAMPLE 2, METHOD 2, RUN 2 INPUT FILE

```
EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
2024 T3  SHEET
2.2374E-09      0.70     3.3386 6.2126E-9      0.00     2.9783
   116.00       36.0       53.0       2.0       2.3       0.99     -0.99
   10.426      -.366      0.887   10700.0     0.022      1.000       1.0      1.0
   0.900       1.390      0.188     0.188     .0500      8.180     0.050    0.188
0.2020E+000.1010E+010.1370E-010.1330E+000.2690E+020.4840E+020.1880E+000.8800E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.2570E+000.1050E-030.0000E+000.0000E+000.0000E+000.0000E+00
    0.188     0.1250       9.82      8.18  0.00000    .00000    99.900  50. 1.00
   0.1250     0.0000       1.64      0.00  0.00000    .00000   0.00000   .00000
   0.000      0.0000
   1   36     2    1     1  100 1040 1030
    0.000      0.000      0.000     0.000     0.000      0.000     0.000    0.000
    120.0       25.0      6000.         1
```

TABLE 3.2.2-4. EXAMPLE 2, METHOD 2, RUN 2 OUTPUT FILE

```
      *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM    D A M G R O  *****

 EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING  SPECTRUM

    * THIS ANALYSIS RESTARTS WITH THE STRESS SPECTRUM AT STEP  36 *

NO. OF SITES TO BE ANALYZED :   CRACK GROWTH =    2;  CRACK INITIATION =    1
 CORRESPONDING DAMAGE CODES :   CRACK GROWTH = 1040;  CRACK INITIATION = 1030

LOAD INTERACTION :      GENERALIZED WILLENBORG ET AL--CHANG MODEL

MATERIAL :    2024-T3  SHEET
    WALKER EQ. CONST. (+R) :  C = 0.224E-08,  M =0.700,  N =3.339
    WALKER EQ. CONST. (-R) :  C = 0.621E-08,  M =0.000,  N =2.978
    MAX.  K  FOR DC/DN THRESHOLD = 2.000
    RETARDATION SHUT-OFF RATIO = 2.300
    +R CUT-OFF = 0.9900,    -R CUT-OFF = -0.9900
    YIELD STRENGTH :  53.000
    ELASTIC MODULUS = 0.1070E+05
    PL. STRESS FRACT. TOUGHNESS =  116.00
    PL. STRAIN FRACT. TOUGHNESS = 36.00
    DAMAGE INDEX FOR CRACK INITIATION =  0.887
    NEUBER MATERIAL CONST. = 0.022
    CRACK INITIATION EQ. CONST. :  SF = 10.426,  M =-.366
    STRESS SEVERITY FACTOR PARAMETERS :
      ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :
    INITIAL CRACK LENGTH OF CRACK NO. 1 :    0.90100
    FINAL CRACK LENGTH OF CRACK NO. 1 :      1.39000
    INITIAL CRACK DEPTH OF CRACK NO. 1 :     0.18800
    FINAL CRACK DEPTH OF CRACK NO. 1 :       0.18800
    INITIAL CRACK LENGTH OF CRACK NO. 2 :    0.05000
    FINAL CRACK LENGTH OF CRACK NO. 2 :      8.18000
    INITIAL CRACK DEPTH OF CRACK NO. 2 :     0.05000
    FINAL CRACK DEPTH OF CRACK NO. 2 :       0.18800
    PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY
      APAOL1 = .202E+00, APCOL1 = .101E+01, RYAOL1 = .137E-01, RYCOL1 = .133E+00
       AKOL1 = .269E+02,  CKOL1 = .484E+02,    AOL1 = .188E+00,   COL1 = .880E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,    AOL2 = .000E+00,   COL2 = .000E+00
    PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY
        DMG1 = .257E+00, DMGOL1 =.105E-03,  DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.2.2-4. EXAMPLE 2, METHOD 2, RUN 2 OUTPUT FILE (CON'T.)

```
COMPONENT GEOMETRY :
    THICKNESS OF PLATE :                                      0.18800
    RADIUS OF MID. HOLE :                                     0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :            99.89999
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :              9.82000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :              8.18000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :                  0.00000,   0.00000
    RADIUS OF THE R.H.S. HOLE :                               0.12500
    DISTANCE BETWEEN MID. AND R.H.S. HOLES :                  1.64000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :                0.00000,   0.00000
    RADIUS OF THE L.H.S. HOLE :                               0.00000
    DISTANCE BETWEEN MID. AND L.H.S. HOLES :                  0.00000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :                0.00000,   0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :        50.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION :              1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS :                 0.0000
    FAYING SURFACE FRICTION STRESS :                          0.0000

STRESS SPECTRUM :
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                    100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                       7416.500
    TOTAL NO. OF FLIGHTS IN ONE BLOCK :                       120.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME :                     25.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :            . 6000.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM :                      35.750
    NO. OF STRESS LAYERS IN ONE BLOCK                         204

UNSTABLE BREAK-THROUGH OF CRACK NO. 2 OCCURS AT :
  CYC =    0.0,  STEP =  36,  BLOCK =    1,  DEPTH = 0.05000,  AKMAXS= 52.24
```

TABLE 3.2.2-4. EXAMPLE 2, METHOD 2, RUN 2 OUTPUT FILE (CONCLUDED)

```
        *******   D A M A G E   G R O W T H   H I S T O R Y   *******

BLOCK      C1        C2     KMAX-C1  KMAX-C2   DC1/DF     DC2/DF    INITIA1    INITIA2
           A1        A2     KMAX-A1  KMAX-A2   DA1/DF     DA2/DF      KN1        KN2
  0.0   0.90100   0.05000    49.490   41.685  .000E+00  .000E+00  .259E+00  .000E+00
        0.18800   0.05000     0.000   52.244  .000E+00  .000E+00  .263E+01  .000E+00
  1.0   1.21853   0.45006    67.869   63.073  .265E-02  .333E-02  .272E+00  .000E+00
        0.18800   0.18800     0.000    0.000  .000E+00  .115E-02  .263E+01  .000E+00

UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:
    CYC =    1.0,  STEP = 34,  BLOCK =  2,  CRACK LENGTH = 1.37721,  CKMAXS=126.59
THE OTHER CRACK LENGTH = 0.53209
TERMINATE DAMAGE COMPUTATION


    RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
      APAOL1 = .202E+00, APCOL1 = .189E+01, RYAOL1 = .137E-01, RYCOL1 = .529E+00
       AKOL1 = .269E+02,  CKOL1 = .966E+02,   AOL1 = .188E+00,   COL1 = .136E+01
      APAOL2 = .000E+00, APCOL2 = .763E+00, RYAOL2 = .000E+00, RYCOL2 = .243E+00
       AKOL2 = .000E+00,  CKOL2 = .655E+02,   AOL2 = .000E+00,   COL2 = .520E+00
    RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
        DMG1 = .277E+00, DMGOL1 =.732E-04,  DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.2.2-5. EXAMPLE 2, METHOD 2, RUN 3 INPUT FILE

```
 EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
2024-T3  SHEET
2.2374E-09      0.70     3.3386 6.2126E-9      0.00      2.9783
   116.00       36.0       53.0       2.0       2.3       0.99     -0.99
   10.426      -.366      0.887   10700.0     0.022      1.000       1.0       1.0
    0.532      8.180      0.188     0.188     .0000      0.000     0.000     0.000
0.0000E+000.7630E+000.0000E+000.2430E+000.0000E+000.6550E+020.0000E+000.5200E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.2770E+000.7320E-040.0000E+000.0000E+000.0000E+000.0000E+00
    0.188     0.1250       8.18      9.82   0.00000    .00000     99.900  50. 1.00
   0.0000     0.1250       0.00      1.64   0.00000    .00000    0.00000    .00000
    0.000     0.0000
   1   34    1    1    1  100 1030 1050
    0.000      0.000      0.000     0.000     0.000      0.000     0.000     0.000
    120.0       25.0      6000.         1
```

TABLE 3.2.2-6. EXAMPLE 2, METHOD 2, RUN 3 OUTPUT FILE

```
      *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM   D A M G R O  *****

   EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM

     * THIS ANALYSIS RESTARTS WITH THE STRESS SPECTRUM AT STEP  34 *

NO. OF SITES TO BE ANALYZED :    CRACK GROWTH =    1;  CRACK INITIATION =    1
 CORRESPONDING DAMAGE CODES :    CRACK GROWTH = 1030;  CRACK INITIATION = 1050

LOAD INTERACTION :      GENERALIZED WILLENBORG ET AL--CHANG MODEL

MATERIAL :   2024-T3  SHEET
    WALKER EQ. CONST. (+R) :  C = 0.224E-08,  M =0.700,  N =3.339
    WALKER EQ. CONST. (-R) :  C = 0.621E-08,  M =0.000,  N =2.978
    MAX.  K  FOR DC/DN THRESHOLD = 2.000
    RETARDATION SHUT-OFF RATIO = 2.300
    +R CUT-OFF = 0.9900,   -R CUT-OFF = -0.9900
    YIELD STRENGTH :  53.000
    ELASTIC MODULUS = 0.1070E+05
    PL. STRESS FRACT. TOUGHNESS =  116.00
    PL. STRAIN FRACT. TOUGHNESS = 36.00
    DAMAGE INDEX FOR CRACK INITIATION =  0.887
    NEUBER MATERIAL CONST. = 0.022
    CRACK INITIATION EQ. CONST. :  SF = 10.426,  M =-.366
    STRESS SEVERITY FACTOR PARAMETERS :
      ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :
    INITIAL CRACK LENGTH OF CRACK NO. 1 :    0.53200
    FINAL CRACK LENGTH OF CRACK NO. 1 :      8.18000
    INITIAL CRACK DEPTH OF CRACK NO. 1 :     0.18800
    FINAL CRACK DEPTH OF CRACK NO. 1 :       0.18800
    INITIAL CRACK LENGTH OF CRACK NO. 2 :    0.00000
    FINAL CRACK LENGTH OF CRACK NO. 2 :      0.00000
    INITIAL CRACK DEPTH OF CRACK NO. 2 :     0.00000
    FINAL CRACK DEPTH OF CRACK NO. 2 :       0.00000
    PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :
      APAOL1 = .122E-77, APCOL1 = .763E+00, RYAOL1 = .000E+00, RYCOL1 = .243E+00
       AKOL1 = .000E+00,  CKOL1 = .655E+02,   AOL1 = .000E+00,   COL1 = .520E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :
        DMG1 = .277E+00, DMGOL1 =.732E-04,  DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.2.2-6. EXAMPLE 2, METHOD 2, RUN 3 OUTPUT FILE (CON'T.)

```
COMPONENT GEOMETRY :
    THICKNESS OF PLATE :                                        0.18800
    RADIUS OF MID. HOLE :                                       0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :              99.89999
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :                8.18000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :                9.82000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :                    0.00000,   0.00000
    RADIUS OF THE R.H.S. HOLE :                                 0.00000
    DISTANCE BETWEEN MID. AND R.H.S. HOLES :                    0.00000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :                  0.00000,   0.00000
    RADIUS OF THE L.H.S. HOLE :                                 0.12500
    DISTANCE BETWEEN MID. AND L.H.S. HOLES :                    1.64000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :                  0.00000,   0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :          50.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION :                1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS :                   0.0000
    FAYING SURFACE FRICTION STRESS :                            0.0000

STRESS SPECTRUM :
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                      100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                         7416.500
    TOTAL NO. OF FLIGHTS IN ONE BLOCK :                         120.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME :                       25.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :               6000.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM :                        35.750
    NO. OF STRESS LAYERS IN ONE BLOCK :                         204
```

TABLE 3.2.2-6. EXAMPLE 2, METHOD 2, RUN 3 OUTPUT FILE (CONCLUDED)

```
       *******   D A M A G E   G R O W T H   H I S T O R Y   *******

BLOCK        C1        C2    KMAX-C1  KMAX-C2     DC1/DF      DC2/DF    INITIA1    INITIA2
             A1        A2    KMAX-A1  KMAX-A2     DA1/DF      DA2/DF        KN1        KN2
  0.0   0.53200   0.00000     77.318    0.000   .000E+00    .000E+00   .281E+00   .000E+00
        0.18800   0.00000      0.000    0.000   .000E+00    .000E+00   .546E+01   .000E+00


CRACK INITIATION FOR LOCATION  1  OCCURS AT :
    CYC =  28.000,   STEP =  96,   BLOCK =   1

    CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
          C1 = 1.04419,   A1 = 0.18800,   C2 = 0.00000,   A2 = 0.00000


    RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
      APAOL1 = .122E-77, APCOL1 = .129E+01, RYAOL1 = .000E+00, RYCOL1 = .251E+00
       AKOL1 = .000E+00,  CKOL1 = .666E+02,    AOL1 = .000E+00,    COL1 = .104E+01
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,    AOL2 = .000E+00,    COL2 = .000E+00
    RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
        DMG1 = .879E+00, DMGOL1 =.780E-02,  DELDG1 =.574E-02
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.2.2-7. EXAMPLE 2, METHOD 2, RUN 4 INPUT FILE

```
 EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
2024-T3  SHEET
2.2374E 09      0.70     3.3386 6.2126E-9      0.00     2.9783
   116.00       36.0       53.0       2.0       2.3       0.99     -0.99
   10.426      -.366      0.887   10700.0     0.022      1.000       1.0       1.0
   1.044       8.180      0.188     0.188     .0500      8.180     0.050     0.188
0.0000E 000.1290E+010.0000E+000.2510E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.8790E+000.7800E-020.5740E-020.0000E+000.0000E+000.0000E+00
     0.188     0.1250       8.18      9.82   0.00000     .00000    99.900  50. 1.00
    0.0000     0.1250       0.00      1.64   0.00000     .00000   0.00000    .00000
    0.000      0.0000
    1   96     2    0      1  100 1050 0000
     0.000      0.000      0.000     0.000     0.000      0.000     0.000     0.000
     120.0       25.0      6000.         1
```

TABLE 3.2.2-8. EXAMPLE 2, METHOD 2, RUN 4 OUTPUT FILE

```
   *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM    D A M G R O  *****

 EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING  SPECTRUM

    * THIS ANALYSIS RESTARTS WITH THE STRESS SPECTRUM AT STEP  96 *

NO. OF SITES TO BE ANALYZED :    CRACK GROWTH =    2;  CRACK INITIATION =    0
 CORRESPONDING DAMAGE CODES :    CRACK GROWTH = 1050;  CRACK INITIATION =    0

LOAD INTERACTION :       GENERALIZED WILLENBORG ET AL--CHANG MODEL

MATERIAL :    2024-T3  SHEET
    WALKER EQ. CONST. (+R)      C = 0.224E-08,  M =0.700,  N =3.339
    WALKER EQ. CONST. (-R) :  C = 0.621E-08,  M =0.000,  N =2.978
    MAX.  K  FOR DC/DN THRESHOLD = 2.000
    RETARDATION SHUT-OFF RATIO = 2.300
    +R CUT-OFF = 0.9900,    -R CUT-OFF = -0.9900
    YIELD STRENGTH :   53.000
    ELASTIC MODULUS = 0.1070E+05
    PL. STRESS FRACT. TOUGHNESS =  116.00
    PL. STRAIN FRACT. TOUGHNESS = 36.00
    DAMAGE INDEX FOR CRACK INITIATION =  0.887
    NEUBER MATERIAL CONST. = 0.022
    CRACK INITIATION EQ. CONST. :   SF = 10.426,  M =-.366
    STRESS SEVERITY FACTOR PARAMETERS :
      ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :
    INITIAL CRACK LENGTH OF CRACK NO. 1 :    1.04400
    FINAL CRACK LENGTH OF CRACK NO. 1 :      8.18000
    INITIAL CRACK DEPTH OF CRACK NO. 1       0.18800
    FINAL CRACK DEPTH OF CRACK NO. 1 :       0.18800
    INITIAL CRACK LENGTH OF CRACK NO. 2 :    0.05000
    FINAL CRACK LENGTH OF CRACK NO. 2 :      8.18000
    INITIAL CRACK DEPTH OF CRACK NO. 2 .     0.05000
    FINAL CRACK DEPTH OF CRACK NO. 2 :       0.18800
    PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :
      APAOL1 = .122E-77, APCOL1 = .129E+01, RYAOL1 = .000E+00, RYCOL1 = .251E+00
       AKOL1 = .000E+00,  CKOL1 = .666E+02,   AOL1 = .000E+00,   COL1 = .104E+01
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY
        DMG1 = .879E+00, DMGOL1 =.780E-02,  DELTA1 =.574E-02
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELTA2 =.000E+00
```

TABLE 3.2.2-8. EXAMPLE 2, METHOD 2, RUN 4 OUTPUT FILE (CON'T.)

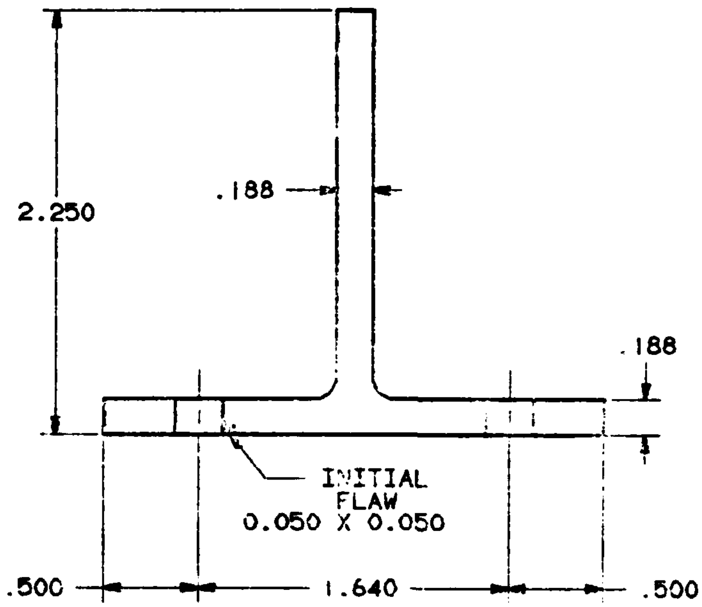
```
COMPONENT GEOMETRY :
    THICKNESS OF PLATE :                                      0.18800
    RADIUS OF MID. HOLE :                                     0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :            99.89999
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :              8.18000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :              9.82000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :                  0.00000,  0.00000
    RADIUS OF THE R.H.S. HOLE :                               0.00000
    DISTANCE BETWEEN MID. AND R.H.S. HOLES :                  0.00000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :                0.00000,  0.00000
    RADIUS OF THE L.H.S. HOLE :                               0.12500
    DISTANCE BETWEEN MID. AND L.H.S. HOLES :                  1.64000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :                0.00000,  0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :        50.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION :              1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS :                 0.0000
    FAYING SURFACE FRICTION STRESS :                          0.0000

STRESS SPECTRUM :
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                    100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                       7416.500
    TOTAL NO. OF FLIGHTS IN ONE BLOCK :                       120.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME :                     5.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :             6000.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM :                     35.750
    NO. OF STRESS LAYERS IN ONE BLOCK                         204

UNSTABLE BREAK-THROUGH OF CRACK NO. 2 OCCURS AT :
  CYC =    0.0,  STEP =  96,  BLOCK =   1,  DEPTH = 0.05000,  AKMAXS= 75.65
```

TABLE 3.2.2-8. EXAMPLE 2, METHOD 2, RUN 4 OUTPUT FILE (CONCLUDED)

```
         *******    D A M A G E    G R O W T H    H I S T O R Y    *******

BLOCK        C1        C2      KMAX-C1  KMAX-C2    DC1/DF      DC2/DF     INITIA1    INITIA2
             A1        A2      KMAX-A1  KMAX-A2    DA1/DF      DA2/DF       KN1        KN2
  0.0   1.04400   0.05000    83.509   60.363   .000E+00   .000E+00   .879E+00   .000E+00
        0.10800   0.05000     0.000   75.652   .000E+00   .000E+00   .000E+00   .000E+00

UNSTABLE GROWTH OF CRACK NO. 2 OCCURS AT:
    CYC =    1.0,   STEP =   1,   BLOCK =   2,   CRACK LENGTH = 1.42785,   CKMAX3=116.00
THE OTHER CRACK LENGTH = 2.22758
TERMINATE DAMAGE COMPUTATION
  1.0   2.20552   1.22989   112.207  113.402   .968E-02   .983E-02   .879E+00   .000E+00
        0.18800   0.18800     0.000    0.000   .000E+00   .115E-02   .000E+00   .000E+00


    RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
      APAOL1 = .122E-77, APCOL1 = .286E+01, RYAOL1 = .000E+00, RYCOL1 = .634E+00
       AKOL1 = .000E+00,  CKOL1 = .106E+03,    AOL1 = .000E+00,    COL1 = .223E+01
      APAOL2 = .000E+00, APCOL2 = .209E+01, RYAOL2 = .000E+00, RYCOL2 = .672E+00
       AKOL2 = .000E+00,  CKOL2 = .109E+03,    AOL2 = .000E+00,    COL2 = .141E+01
    RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
        DMG1 = .879E+00, DMGOL1 =.780E-02,  DELDG1 =.574E-02
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

EXAMPLE 3: STRINGER SECTION SUBJECTED TO CONSTANT AMPLITUDE LOADING

GEOMETRY:



MATERIAL:

2024-T351 EXTRUSION

LOADING SPECTRUM:

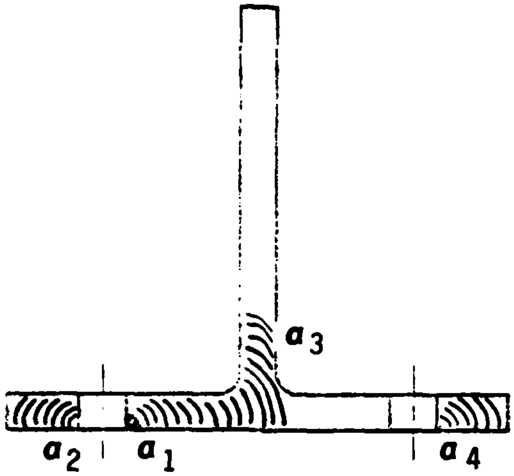
CONSTANT AMPLITUDE

σ_{max} = 17.0 KSI
σ_{min} = 1.70 KSI

REF. PAGES 92 THROUGH 107

TABLE 3.3.1. EXAMPLE 3, METHOD 1 SUMMARY TABLE

REF. PAGES 93 THROUGH 99



a_1 (IN)	a_2 (IN)	a_3 (IN)	a_4 (IN)	LIFE (CYCLES)	ROUTINE GROWTH	RUN NO.
.050	0	0	0	0	2020	1
.056	0	0	0	2020	2020	1
.066	0	0	0	4000	2020	1
.080	0	0	0	6000	2020	1
.101	0	0	0	8000	2020	1
.131	0	0	0	10000	2020	1
.181	0	0	0	12000	2020	1
.248	0	0	0	14000	2020	1
.336	0	0	0	16000	2020	1
.447	0	0	0	18000	2020	1
.567	0	0	0	20000	2020	1
.700	0	0	0	22000	2020	1
.873	0	.265	0	23878	2050	2
1.089	0		0	25878	2050	2
1.396	0	.304	0	26739	2050	2

NO. OF CYCLES TO FAILURE = 26,739 CYCLES

TABLE 3.3.1-1. EXAMPLE 3, METHOD 1, RUN 1 INPUT FILE

```
   EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMLITUDE LOADING
2024-T351 EXTRUSION
0.1600E-09       0.65      4.554  0.230E-08      1.00      3.115
    58.00        36.0       53.3       2.0        2.3       0.99      -0.99
  10.4260      -.3660      0.872   10700.0      0.022        1.0        1.0        1.0
     .050       1.390      0.050     0.188      0.000      0.000      0.000      0.000
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E-000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E-000.0000E+000.0000E+00
    0.188      0.1250       2.14     0.500    0.00000    0.00000    99.9999  0.0 1.00
   0.1250      0.0000     -1.640     0.000      0.000      0.000      0.000     .00000
    0.000      0.0000
    0   00      1    0     0  100 2010 0000
    1.226       1.414      0.462     1.000     0.2658      .0000     0.0000      0.000
    000.0        00.0     00000.         1
```

TABLE 3.3.1-2. EXAMPLE 3, METHOD 1, RUN 1 OUTPUT FILE

```
       *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM    D A M G R O  *****

   EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING

       * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED :    CRACK GROWTH =    1;  CRACK INITIATION =    0
 CORRESPONDING DAMAGE CODES :    CRACK GROWTH = 2010;  CRACK INITIATION =    0

LOAD INTERACTION :       NONE

MATERIAL :     2024-T351   EXTRUSION
    WALKER EQ. CONST. (+R) :   C = 0.160E-09,   M =0.650,   N =4.554
    WALKER EQ. CONST. (-R) :   C = 0.230E-08,   M =1.000,   N =3.115
    MAX.  K  FOR DC/DN THRESHOLD = 2.000
    RETARDATION SHUT-OFF RATIO = 2.300
    +R CUT-OFF = 0.9900,    -R CUT OFF = -0.9900
    YIELD STRENGTH :   53.300
    ELASTIC MODULUS = 0.1070E+05
    PL. STRESS FRACT. TOUGHNESS =    58.00
    PL. STRAIN FRACT. TOUGHNESS = 36.00
    DAMAGE INDEX FOR CRACK INITIATION =  0.872
    NEUBER MATERIAL CONST. = 0.022
    CRACK INITIATION EQ. CONST. :   SF = 10.426,   M =-.366
    STRESS SEVERITY FACTOR PARAMETERS
      ALPHA = 1.0000,   BETA = 1.0000,   GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :
    INITIAL CRACK LENGTH OF CRACK NO. 1 :    0.05000
    FINAL CRACK LENGTH OF CRACK NO. 1        1.39000
    INITIAL CRACK DEPTH OF CRACK NO. 1 :     0.05000
    FINAL CRACK DEPTH OF CRACK NO. 1         0.18800
    INITIAL CRACK LENGTH OF CRACK NO. 2      0.00000
    FINAL CRACK LENGTH OF CRACK NO. 2        0.00000
    INITIAL CRACK DEPTH OF CRACK NO. 2       0.00000
    FINAL CRACK DEPTH OF CRACK NO. 2         0.00000
    PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY
        DMG1 = .000E+00, DMGOL1 =.000E+00,  DELDG1 =.000E+00
        DMG2   .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.3.1-2. EXAMPLE 3, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

```
COMPONENT GEOMETRY :
    THICKNESS OF PLATE :                                         0.18800
    RADIUS OF MID. HOLE :                                        0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :               99.99989
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :                 2.14000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :                 0.50000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :                     0.00000,  0.00000
    RADIUS OF THE R.H.S. HOLE :                                  0.12500
    DISTANCE BETWEEN MID. AND R.H.S. HOLES :                     1.64000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :                   0.00000,  0.00000
    RADIUS OF THE L.H.S. HOLE :                                  0.00000
    DISTANCE BETWEEN MID. AND L.H.S. HOLES :                     0.00000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :                   0.00000,  0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :            0.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION :                 1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS :                    0.0000
    FAYING SURFACE FRICTION STRESS :                             0.0000

USER DEFINED VARIABLES :
    VARIABLE 1 :         1.2260
    VARIABLE 2 :         1.4140
    VARIABLE 3 :         0.4620
    VARIABLE 4 :         1.0000
    VARIABLE 5 :         0.2658
    VARIABLE 6 :         0.0000
    VARIABLE 7 :         0.0000
    VARIABLE 8 :         0.0000

STRESS SPECTRUM :
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                       100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                          2000.000
    TOTAL NO. OF FLIGHTS IN ONE BLOCK :                            0.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME                           0.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :                   0.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM :                         17.000
    NO. OF STRESS LAYERS IN ONE BLOCK                              2


STRESS LAYERS IN ONE BLOCK :
  STEP SIGMA-MAX   SIGMA-MIN   CYCLES          STEP SIGMA-MAX   SIGMA-MIN   CYCLES
    1    17.000       1.700  1000.000             2    17.000       1.700  1000.000
```

TABLE 3.3.1-2. EXAMPLE 3, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

******* D A M A G E G R O W T H H I S T O R Y *******

BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
0.0	0.05000	0.00000	8.892	0.000	.000E+00	.000E+00	.000E+00	.000E+00
	0.05000	0.00000	11.144	0.000	.000E+00	.000E+00	.000E+00	.000E+00
1.0	0.05629	0.00000	9.900	0.000	.315E-05	.000E+00	.000E+00	.000E+00
	0.06504	0.00000	11.627	0.000	.752E-05	.000E+00	.000E+00	.000E+00
2.0	0.06611	0.00000	10.802	0.000	.491E-05	.000E+00	.000E+00	.000E+00
	0.08344	0.00000	12.171	0.000	.920E-05	.000E+00	.000E+00	.000E+00
3.0	0.08041	0.00000	11.684	0.000	.715E-05	.000E+00	.000E+00	.000E+00
	0.10629	0.00000	12.774	0.000	.114E-04	.000E+00	.000E+00	.000E+00
4.0	0.10084	0.00000	12.647	0.000	.102E-04	.000E+00	.000E+00	.000E+00
	0.13484	0.00000	13.415	0.000	.143E-04	.000E+00	.000E+00	.000E+00

STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :
CYC= 887.0, STEP = 1, BLOCK = 6, CRACK DEPTH = 0.18911
CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS 0.1880 INCHES

5.0	0.13082	0.00000	13.827	0.000	.150E-04	.000E+00	.000E+00	.000E+00
	0.17055	0.00000	14.088	0.000	.179E-04	.000E+00	.000E+00	.000E+00
6.0	0.18029	0.00000	15.384	0.000	.247E-04	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.873E-05	.000E+00	.000E+00	.000E+00
7.0	0.24819	0.00000	16.248	0.000	.340E-04	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
8.0	0.33618	0.00000	17.216	0.000	.440E-04	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
9.0	0.44788	0.00000	17.947	0.000	.558E-04	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
10.0	0.56758	0.00000	17.771	0.000	.599E-04	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
11.0	0.70011	0.00000	18.917	0.000	.663E-04	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00

TABLE 3.3.1-2. EXAMPLE 3, METHOD 1, RUN 1 OUTPUT FILE (CONCLUDED)

```
CRACK NO. 1 EXCEEDS APPLICABLE RANGE OF SUBROUTINE K2010 AT  :
    CYC =  878.0,    STEP =      2,    BLOCK =    12
CHANGE TO K2050 OR K2060.    TERMINATE COMPUTION

    CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION .
          C1 = 0.87354,    A1 = 0.18800,    C2 = 0.00000,    A2 = 0.00000


    RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION
        DMG1 = .000E+00, DMGOL1 =.000E+00,  DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.3.1-3. EXAMPLE 3, METHOD 1, RUN 2 INPUT FILE

```
   EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMLITUDE LOADING
2024-T351 EXTRUSION
0.1600E-09       0.65     4.554  0.230E-08      1.00     3.115
     58.00       36.0      53.3        2.0       2.3      0.99     -0.99
   10.4260     -.3660     0.872    10700.0     0.022       1.0       1.0       1.0
      .866      1.390     0.188      0.188     0.265     2.250     0.188     0.188
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E-000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E-000.0000E+000.0000E+00
     0.188     0.1250      2.14      0.500   0.00000   0.00000   99.9999  0.0 1.00
    0.1250     0.0000     1.640      0.000     0.000     0.000     0.000    .00000
    0.000      0.0000
    0   00     2    0     0  100 2050 0000
     2.256     0.000      0.581      0.416     0.289     .0000     0.1880    0.000
     000.0       00.0    00000.          1
```

TABLE 3.3.1-4. EXAMPLE 3, METHOD 1, RUN 2 OUTPUT FILE

```
   *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM    D A M G R O  *****

 EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING

    * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED :    CRACK GROWTH =    2;  CRACK INITIATION =     0
 CORRESPONDING DAMAGE CODES :    CRACK GROWTH = 2050;  CRACK INITIATION =     0

LOAD INTERACTION :       NONE

MATERIAL :    2024-T351   EXTRUSION
    WALKER EQ. CONST. (+R) :  C = 0.160E-09,  M =0.650,  N =4.554
    WALKER EQ. CONST. (-R) :  C = 0.230E-08,  M =1.000,  N =3.115
    MAX.  K  FOR DC/DN THRESHOLD    2.000
    RETARDATION SHUT-OFF RATIO = 2.300
    +R CUT-OFF = 0.9900,    -R CUT-OFF = -0.9900
    YIELD STRENGTH :  53.300
    ELASTIC MODULUS = 0.1070E+05
    PL. STRESS FRACT. TOUGHNESS =   58.00
    PL. STRAIN FRACT. TOUGHNESS = 36.00
    DAMAGE INDEX FOR CRACK INITIATION =  0.872
    NEUBER MATERIAL CONST. = 0.022
    CRACK INITIATION EQ. CONST. :  SF = 10.426,  M =-.366
    STRESS SEVERITY FACTOR PARAMETERS
      ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :
    INITIAL CRACK LENGTH OF CRACK NO. 1 :    0.86600
    FINAL CRACK LENGTH OF CRACK NO. 1 :      1.39000
    INITIAL CRACK DEPTH OF CRACK NO. 1 :     0.18800
    FINAL CRACK DEPTH OF CRACK NO. 1 :       0.18800
    INITIAL CRACK LENGTH OF CRACK NO. 2 :    0.26500
    FINAL CRACK LENGTH OF CRACK NO. 2 :      2.25000
    INITIAL CRACK DEPTH OF CRACK NO. 2 :     0.18800
    FINAL CRACK DEPTH OF CRACK NO. 2 :       0.18800
    PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :
        DMG1 = .000E+00, DMGO1 =.000E+00,  DELDG1  .000E+00
        DMG2 = .000E+00, DMGO2 =.000E+00,  DELDG2  .000E+00
```

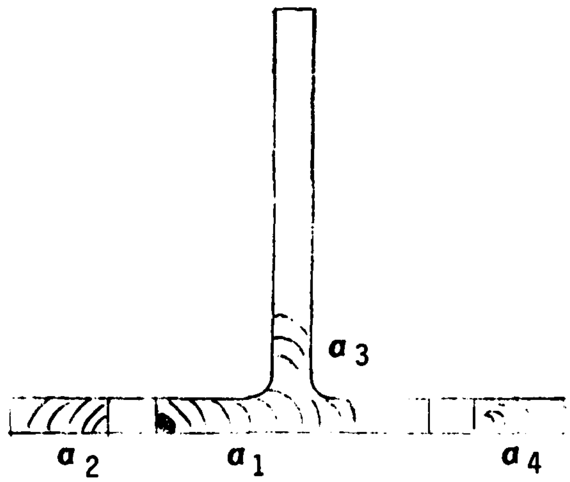
TABLE 3.3.1-4. EXAMPLE 3, METHOD 1, RUN 2 OUTPUT FILE (CON'T.)

```
COMPONENT GEOMETRY :
    THICKNESS OF PLATE :                                          0.18800
    RADIUS OF MID. HOLE :                                         0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D                  99.99989
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :                  2.14000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :                  0.50000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :                      0.00000,   0.00000
    RADIUS OF THE R.H.S. HOLE :                                   0.12500
    DISTANCE BETWEEN MID. AND R.H.S. HOLES                        1.64000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :                    0.00000,   0.00000
    RADIUS OF THE L.H.S. HOLE :                                   0.00000
    DISTANCE BETWEEN MID. AND L.H.S. HOLES                        0.00000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :                    0.00000,   0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :             0.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION :                  1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS                       0.0000
    FAYING SURFACE FRICTION STRESS :                              0.0000

USER DEFINED VARIABLES :
    VARIABLE 1 :           2.2500
    VARIABLE 2 :           0.0000
    VARIABLE 3 :           0.5810
    VARIABLE 4 :           0.4160
    VARIABLE 5             0.2890
    VARIABLE 6             0.0000
    VARIABLE 7             0.1800
    VARIABLE 8             0.0000

STRESS SPECTRUM
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                        100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                         2000.000
    TOTAL NO. OF FLIGHTS IN ONE BLOCK                             0.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME                          0.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME                    0.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM                          17.000
    NO. OF STRESS LAYERS IN ONE BLOCK                             2
```

TABLE 3.3.1-4. EXAMPLE 3, METHOD 1, RUN 2 OUTPUT FILE (CONCLUDED)

```
        *******   D A M A G E   G R O W T H   H I S T O R Y   *******

BLOCK       C1        C2     KMAX-C1   KMAX-C2    DC1/DF     DC2/DF    INITIA1    INITIA2
            A1        A2     KMAX-A1   KMAX-A2    DA1/DF     DA2/DF      KN1        KN2
  0.0  0.86600   0.26500     19.252    13.435   .000E+00   .000E+00   .000E+00   .000E+00
       0.18800   0.18800      0.000     0.000   .000E+00   .000E+00   .000E+00   .000E+00

UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:
    CYC = 861.0,  STEP =   1,  BLOCK =   2,  CRACK LENGTH = 1.39664,  CKMAXS= 70.35
THE OTHER CRACK LENGTH = 0.30423
TERMINATE DAMAGE COMPUTATION
  1.0  1.08907   0.30423     22.419    14.870   .112E-03   .196E-04   .000E+00   .000E+00
       0.18800   0.18800      0.000     0.000   .000E+00   .000E+00   .000E+00   .000E+00


    RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION
        DMG1 = .000E+00, DMGOL1 =.000E+00,  DELDG1 =.000E+00
        DMG2 = .000E+00, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.3.2. EXAMPLE 3, METHOD 2 SUMMARY TABLE
(REF. PAGES 101 THROUGH 107)



a_1 (IN)	a_2 (IN)	a_3 (IN)	a_4 (IN)	LIFE (CYCLES)	ROUTINES GROWTH	ROUTINES INITIATION	RUN NO.
.050	0	0	0	0	2020	1010	1
.056	0	0	0	2020	2020	1010	1
.066	0	0	0	4000	2020	1010	1
.080	0	0	0	6000	2020	1010	1
.101	0	0	0	8000	2020	1010	1
.131	0	0	0	10000	2020	1010	1
.181	0	0	0	12000	2020	1010	1
.248	0	0	0	14000	2020	1010	1
.336	0	0	0	16000	2020	1010	1
.447	0	0	0	18000	2020	1010	1
.567	0	0	0	20000	2020	1010	1
.700	0	0	0	22000	2020	1010	1
.873	0	.265	0	23878	2050	1010	2
1.089	0		0	25878	2050	1010	2
1.396	0	.304	0	26739	2050	1010	2

NO. OF CYCLES TO FAILURE = 26,739 CYCLES

TABLE 3.3.2-1. EXAMPLE 3, METHOD 2, RUN 1 INPUT FILE

```
   EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMLITUDE LOADING
2024-T351 EXTRUSION
0.1600E-09      0.65     4.554  0.230E-08      1.00     3.115
    58.00       36.0      53.3        2.0        2.3      0.99      -0.99
  10.4260     -.3660     0.872   10700.0      0.022       1.0        1.0        1.0
    .050      1.390      0.050     0.138      0.000     0.000      0.000      0.000
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E-000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E-000.0000E+000.0000E+00
    0.188     0.1250      2.14     0.500    0.00000   0.00000    99.9999  0.0 1.00
   0.1250     0.0000     1.640     0.000      0.000     0.000      0.000     .00000
   0.000      0.0000
   0   00     1    2     0   100 2010 1010
    1.226     1.414      0.462     1.000     0.2658     .0000      0.000      0.000
    000.0      00.0    00000.          1
```

TABLE 3.3.2-2. EXAMPLE 3, METHOD 2, RUN 1 OUTPUT FILE

```
      *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM   D A M G R O  *****

   EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING

      * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED :    CRACK GROWTH =    1,  CRACK INITIATION =    2
 CORRESPONDING DAMAGE CODES :    CRACK GROWTH = 2010,  CRACK INITIATION = 1010

LOAD INTERACTION :       NONE

MATERIAL :    2024-T351  EXTRUSION
    WALKER EQ. CONST. (+R) :  C = 0.160E-09,  M =0.650,   N =4.554
    WALKER EQ. CONST. (-R) :  C = 0.230E-08,  M =1.000,   N =3.115
    MAX.  K  FOR DC/DN THRESHOLD = 2.000
    RETARDATION SHUT-OFF RATIO = 2.300
    +R CUT-OFF = 0.9900,    -R CUT-OFF = -0.9900
    YIELD STRENGTH :  53.300
    ELASTIC MODULUS = 0.1070E+05
    PL. STRESS FRACT. TOUGHNESS =   58.00
    PL. STRAIN FRACT. TOUGHNESS = 36.00
    DAMAGE INDEX FOR CRACK INITIATION =  0.872
    NEUBER MATERIAL CONST. = 0.022
    CRACK INITIATION EQ. CONST.     SF = 10.426,  M = .366
    STRESS SEVERITY FACTOR PARAMETERS :
      ALPHA = 1.0000,  BETA = 1.0000,  GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :
    INITIAL CRACK LENGTH OF CRACK NO. 1 :     0.05000
    FINAL CRACK LENGTH OF CRACK NO. 1         1.39000
    INITIAL CRACK DEPTH OF CRACK NO. 1 :      0.05000
    FINAL CRACK DEPTH OF CRACK NO. 1 :        0.18800
    INITIAL CRACK LENGTH OF CRACK NO. 2 :     0.00000
    FINAL CRACK LENGTH OF CRACK NO. 2 :       0.00000
    INITIAL CRACK DEPTH OF CRACK NO. 2        0.00000
    FINAL CRACK DEPTH OF CRACK NO. 2 :        0.00000
    PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY
        DAG1 = .000E+00, DMGOL1 = .000E+00,  DELDG1 =.000E+00
        DAG2 = .000E+00, DMGOL2 =.000E+00,   DELDG2 =.000E+00
```

TABLE 3.3.2-2. EXAMPLE 3, METHOD 2, RUN 1 OUTPUT FILE (CON'T.)

```
COMPONENT GEOMETRY :
    THICKNESS OF PLATE :                                        0.18800
    RADIUS OF MID. HOLE :                                       0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :              99.99989
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :                2.14000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :                0.50000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :                    0.00000,   0.00000
    RADIUS OF THE R.H.S. HOLE :                                 0.12500
    DISTANCE BETWEEN MID. AND R.H.S. HOLES :                    1.64000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :                  0.00000,   0.00000
    RADIUS OF THE L.H.S. HOLE :                                 0.00000
    DISTANCE BETWEEN MID. AND L.H.S. HOLES :                    0.00000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :                  0.00000,   0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :           0.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION :                1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS                     0.0000
    FAYING SURFACE FRICTION STRESS :                            0.0000

USER DEFINED VARIABLES :
    VARIABLE 1 :          1.2260
    VARIABLE 2 :          1.4140
    VARIABLE 3 :          0.4620
    VARIABLE 4 :          1.0000
    VARIABLE 5            0.2658
    VARIABLE 6 :          0.0000
    VARIABLE 7 :          0.0000
    VARIABLE 8 :          0.0000

STRESS SPECTRUM :
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS :                      100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                         2000.000
    TOTAL NO. OF FLIGHTS IN ONE BLOCK :                           0.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME :                        0.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :                  0.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM                          17.000
    NO. OF STRESS LAYERS IN ONE BLOCK                             2
```

TABLE 3.3.2-2. EXAMPLE 3, METHOD 2, RUN 1 OUTPUT FILE (CON'T.)

******* D A M A G E   G R O W T H   H I S T O R Y *******

BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
0.0	0.05000	0.00000	8.892	0.000	.000E+00	.000E+00	.254E-02	.179E-02
	0.05000	0.00000	11.144	0.000	.000E+00	.000E+00	.264E+01	.248E+01
1.0	0.05629	0.00000	9.900	0.000	.315E-05	.000E+00	.778E-02	.537E-02
	0.06504	0.00000	11.627	0.000	.752E-05	.000E+00	.266E+01	.248E+01
2.0	0.06611	0.00000	10.802	0.000	.491E-05	.000E+00	.133E-01	.895E-02
	0.08344	0.00000	12.171	0.000	.920E-05	.000E+00	.269E+01	.248E+01
3.0	0.08041	0.00000	11.684	0.000	.715E-05	.000E+00	.194E-01	.12[illegible]E-01
	0.10629	0.00000	12.774	0.000	.114E-04	.000E+00	.274E+01	.248E+01
4.0	0.10084	0.00000	12.647	0.000	.102E-04	.000E+00	.262E-01	.161E-01
	0.13484	0.00000	13.415	0.000	.143E-04	.000E+00	.280E+01	.248E+01

STABLE BREAK THROUGH OF CRACK NO. 1 OCCURS AT :
CYC= 887.0, STEP = 1, BLOCK = 6, CRACK DEPTH = 0.18911
CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS 0.1880 INCHES

BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
5.0	0.13082	0.00000	13.827	0.000	.150E-04	.000E+00	.342E-01	.197E-01
	0.17055	0.00000	14.088	0.000	.179E-04	.000E+00	.290E+01	.248E+01
6.0	0.18029	0.00000	15.384	0.000	.247E-04	.000E+00	.445E-01	.237E-01
	0.18800	0.00000	0.000	0.000	.873E-05	.000E+00	.305E+01	.248E+01
7.0	0.24819	0.00000	16.248	0.000	.340E-04	.000E+00	.590E-01	.269E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.325E+01	.248E+01
8.0	0.33618	0.00000	17.216	0.000	.440E-04	.000E+00	.808E-01	.304E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.352E+01	.248E+01
9.0	0.44788	0.00000	17.947	0.000	.558E-04	.000E+00	.116E+00	.340E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.385E+01	.248E+01
10.0	0.56758	0.00000	17.771	0.000	.599E-04	.000E+00	.173E+00	.376E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.420E+01	.248E+01
11.0	0.70011	0.00000	18.917	0.000	.663E-04	.000E+00	.265E+00	.41[illegible]E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.459E+01	.248E+01

TABLE 3.3.2-2. EXAMPLE 3, METHOD 2, RUN 1 OUTPUT FILE (CONCLUDED)

```
CRACK NO. 1 EXCEEDS APPLICABLE RANGE OF SUBROUTINE K2010 AT :
    CYC =  878.0,    STEP =     2,    BLOCK =    12
CHANGE TO K2050 OR K2060.   TERMINATE COMPUTION

    CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
         C1 = 0.87354,     A1 = 0.18800,    C2 = 0.00000,    A2 = 0.00000


    RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
      APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
       AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
      APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
       AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
    RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
        DMG1 = .333E+00, DMGOL1 =.000E+00,  DELDG1 =.000E+00
        DMG2 = .430E-01, DMGOL2 =.000E+00,  DELDG2 =.000E+00
```

TABLE 3.3.2-3. EXAMPLE 3, METHOD 2, RUN 2 INPUT FILE

```
   EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMLITUDE LOADING
2024-T351 EXTRUSION
0.1600E-09       0.65     4.554  0.230E 08      1.00     3.115
   58.00         36.0      53.3        2.0       2.3       0.99      -0.99
 10.4260      -.3660     0.872   10700.0      0.022       1.0        1.0        1.0
   .860       1.390     0.188      0.188      0.265      2.250      0.188      0.188
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E 000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E 000.0000E+000.0000E+00
   0.188      0.1250       2.14      0.500   0.00000    0.00000    99.9999  0.0 1.00
  0.1250      0.0000      1.640      0.000     0.000      0.000      0.000     .00000
  0.000       0.0000
  0   00      2     2    0  100 2050 1010
   2.250      0.000      0.581      0.416     0.2890      .0000      0.188      0.000
   000.0        00.0     00000.          1
```

TABLE 3.3.2-4. EXAMPLE 3, METHOD 2, RUN 2 OUTPUT FILE

```
      *****  DETAILED DAMAGE GROWTH ANALYSIS PROGRAM    D A M G R O  *****

   EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING

      * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

 NO. OF SITES TO BE ANALYZED :    CRACK GROWTH =     2;  CRACK INITIATION =    2
  CORRESPONDING DAMAGE CODES :    CRACK GROWTH = 2050;  CRACK INITIATION = 1010

 LOAD INTERACTION :        NONE

 MATERIAL :     2024-T351   EXTRUSION
     WALKER EQ. CONST. (+R) :   C = 0.160E-09,    M =0.650,    N =4.554
     WALKER EQ. CONST. (-R) :   C = 0.230E-08,    M =1.000,    N =3.115
     MAX.  K   FOR DC/DN THRESHOLD = 2.000
     RETARDATION SHUT-OFF RATIO = 2.300
     +R CUT-OFF = 0.9900,    -R CUT-OFF = -0.9900
     YIELD STRENGTH    53.300
     ELASTIC MODULUS = 0.1070E+05
     PL. STRESS FRACT. TOUGHNESS =    58.00
     PL. STRAIN FRACT. TOUGHNESS = 36.00
     DAMAGE INDEX FOR CRACK INITIATION =   0.872
     NEUBER MATERIAL CONST. = 0.022
     CRACK INITIATION EQ. CONST. :   SF = 10.426,   M = -.366
     STRESS SEVERITY FACTOR PARAMETERS :
       ALPHA = 1.0000,   BETA = 1.0000,   GAMMA = 1.0000

 SPECIFIED DAMAGE CONDITIONS :
     INITIAL CRACK LENGTH OF CRACK NO. 1 :     0.86600
     FINAL CRACK LENGTH OF CRACK NO. 1 :       1.39000
     INITIAL CRACK DEPTH OF CRACK NO. 1 :      0.18800
     FINAL CRACK DEPTH OF CRACK NO. 1 :        0.18800
     INITIAL CRACK LENGTH OF CRACK NO. 2 :     0.26500
     FINAL CRACK LENGTH OF CRACK NO. 2 :       2.25000
     INITIAL CRACK DEPTH OF CRACK NO. 2 :      0.18800
     FINAL CRACK DEPTH OF CRACK NO. 2 :        0.18800
     PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :
       APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
        AKOL1 = .000E+00,  CPOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
       APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
        AKOL2 = .000E+00,  CPOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
     PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY
         DMG1 = .333E+00, DMGOL1 =.000E+00,  DELDG1 = .000E+00
         DMG2 = .430E-01, DMGOL2 = .000E+00,  DELDG2 = .000E+00
```

TABLE 3.3.2-4. EXAMPLE 3, METHOD 2, RUN 2 OUTPUT FILE (CON'T.)

```
COMPONENT GEOMETRY :
    THICKNESS OF PLATE :                                     0.18800
    RADIUS OF MID. HOLE :                                    0.12500
    RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :           99.99989
    DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :             2.14000
    DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :             0.50000
    FRACTION OF LOAD TRANSFER BY MID. BOLT :                 0.00000,   0.00000
    RADIUS OF THE R.H.S. HOLE :                              0.12500
    DISTANCE BETWEEN MID. AND R.H.S. HOLES :                 1.64000
    FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :               0.00000,   0.00000
    RADIUS OF THE L.H.S. HOLE :                              0.00000
    DISTANCE BETWEEN MID. AND L.H.S. HOLES :                 0.00000
    FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :               0.00000,   0.00000
    PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :        0.0
    STRESS CONCENTRATION DUE TO PIN DEFLECTION :             1.00
    FASTENER HEAD OR COLLAR FRICTION STRESS                  0.0000
    FAYING SURFACE FRICTION STRESS :                         0.0000

USER DEFINED VARIABLES :
    VARIABLE 1 :          2.2500
    VARIABLE 2 :          0.0000
    VARIABLE 3 :          0.5810
    VARIABLE 4 :          0.4160
    VARIABLE 5 :          0.2890
    VARIABLE 6 :          0.0000
    VARIABLE 7 :          0.1880
    VARIABLE 8 :          0.0000

STRESS SPECTRUM :
    NO. OF BLOCKS SPECIFIED FOR ANALYSIS                     100
    TOTAL NO. OF CYCLES IN ONE BLOCK :                      2000.000
    TOTAL NO. OF FLIGHTS IN ONE BLOCK :                        0.000
    NO. OF BLOCKS IN ONE DESIGN LIFETIME :                     0.000
    NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :               0.000
    MAXIMUM PEAK STRESS OF THE SPECTRUM :                     17.000
    NO. OF STRESS LAYERS IN ONE BLOCK                          2
```

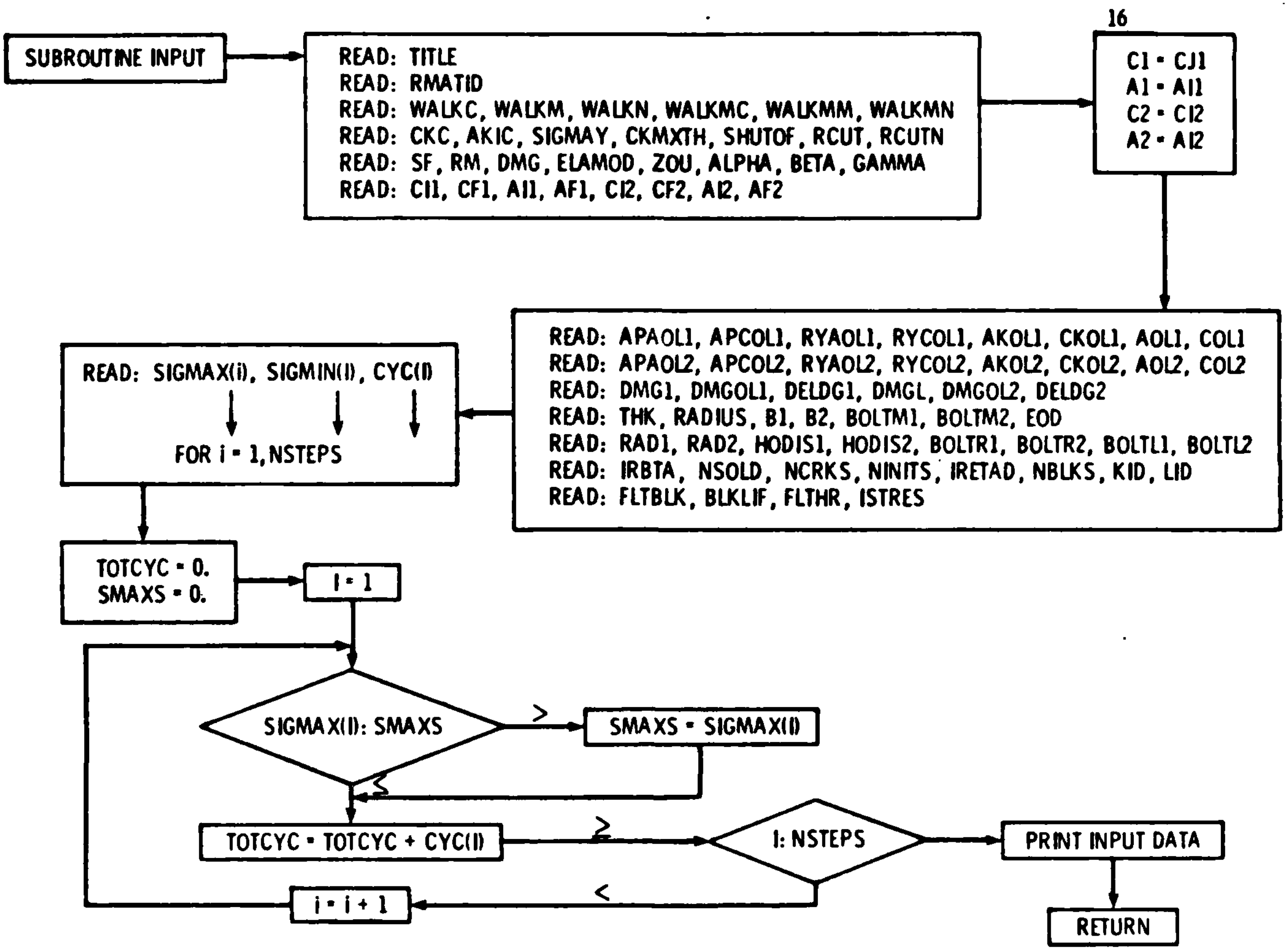
TABLE 3.3.2-4. EXAMPLE 3, METHOD 2, RUN 2 OUTPUT FILE (CONCLUDED)

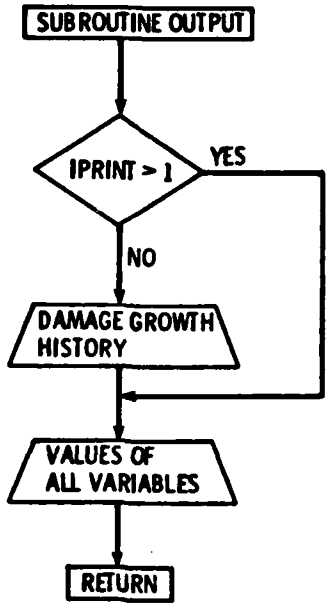
```
          *******   D A M A G E   G R O W T H   H I S T O R Y   *******

  BLOCK       C1        C2     KMAX-C1   KMAX-C2    DC1/DF     DC2/DF    INITIA1    INITIA2
              A1        A2     KMAX-A1   KMAX-A2    DA1/DF     DA2/DF      KN1        KN2
    0.0   0.06600   0.26500    19.252    13.435   .000E+00   .000E+00   .423E+00   .448E-01
          0.18800   0.18800     0.000     0.000   .000E+00   .000E+00   .507E+01   .248E+01

  UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:
      CYC = 861.0,   STEP =   1,   BLOCK =   2,   CRACK LENGTH = 1.39664,   CKMAXS= 70.35
  THE OTHER CRACK LENGTH = 0.30423
  TERMINATE DAMAGE COMPUTATION
    1.0   1.0896.   0.30423    22.419    14.870   .112E-03   .196E-04   .721E+00   .484E-01
          0.18800   0.18800     0.000     0.000   .000E+00   .000E+00   .575E+01   .248E+01

      RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
        APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
         AKOL1 = .000E+00,  CKOL1 = .000E+00,   AOL1 = .000E+00,   COL1 = .000E+00
        APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
         AKOL2 = .000E+00,  CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
      RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
          DMG1 = .721E+00, DMGOL1 =.000E+00,   DELDG1 =.000E+00
          DMG2 = .484E-01, DMGOL2 =.000E+00,   DELDG2 =.000E+00
```

APPENDIX A

COMPUTER PROGRAM FLOW CHARTS

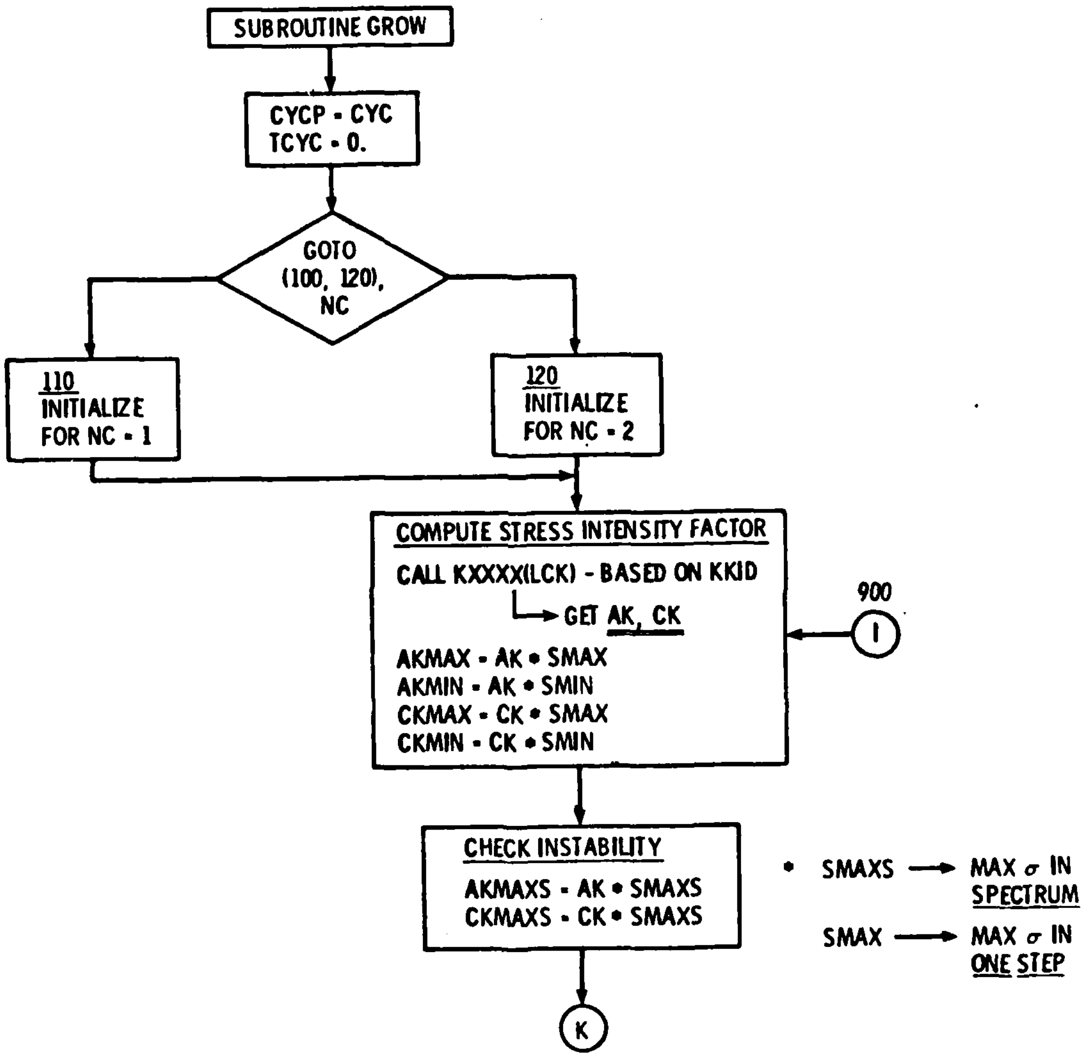
This section presents the flow charts of the various subroutines available in the Computer Program "DAMGRO". The analytical formualtion associated with the various parameters were derived during Phase I of the program, and defined in Volume II of the Report.

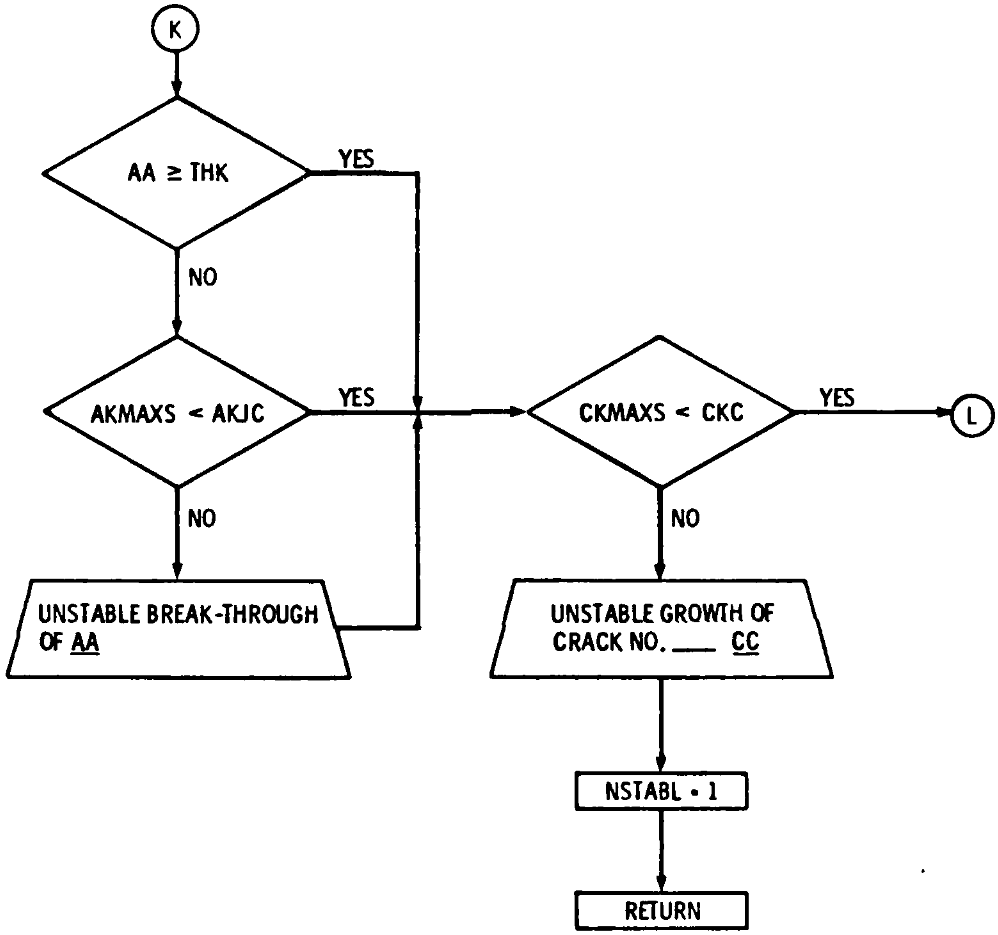

16
SUBROUTINE INPUT
READ: TITLE
READ: RMATID
READ: WALKC, WALKM, WALKN, WALKMC, WALKMM, WALKMN
READ: CKC, AKIC, SIGMAY, CKMXTH, SHUTOF, RCUT, RCUTN
READ: SF, RM, DMG, ELAMOD, ZOU, ALPHA, BETA, GAMMA
READ: CI1, CF1, AI1, AF1, CI2, CF2, AI2, AF2
C1 = CI1
A1 = AI1
C2 = CI2
A2 = AI2
READ: APAOL1, APCOL1, RYAOL1, RYCOL1, AKOL1, CKOL1, AOL1, COL1
READ: APAOL2, APCOL2, RYAOL2, RYCOL2, AKOL2, CKOL2, AOL2, COL2
READ: DMG1, DMGOL1, DELDG1, DMGL, DMGOL2, DELDG2
READ: THK, RADIUS, B1, B2, BOLTM1, BOLTM2, EOD
READ: RAD1, RAD2, HODIS1, HODIS2, BOLTR1, BOLTR2, BOLTL1, BOLTL2
READ: IRBTA, NSOLD, NCRKS, NINITS, IRETAD, NBLKS, KID, LID
READ: FLTBLK, BLKLIF, FLTHR, ISTRES
READ: SIGMAX(i), SIGMIN(I), CYC(I)
FOR i = 1, NSTEPS
TOTCYC = 0.
SMAXS = 0.
I = 1
SIGMAX(I): SMAXS
>
SMAXS = SIGMAX(I)
≤
TOTCYC = TOTCYC + CYC(I)
≥
I: NSTEPS
PRINT INPUT DATA
RETURN
<
i = i + 1

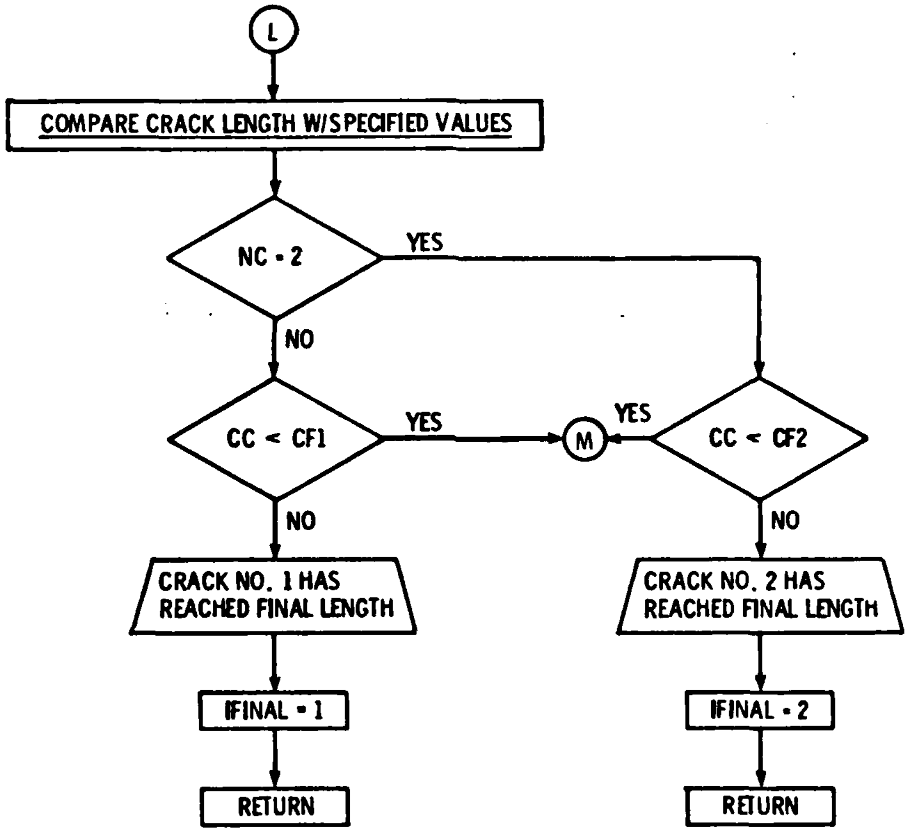

SUBROUTINE OUTPUT
IPRINT > 1
YES
NO
DAMAGE GROWTH HISTORY
VALUES OF ALL VARIABLES
RETURN

BLOCK DATA → DEFINE

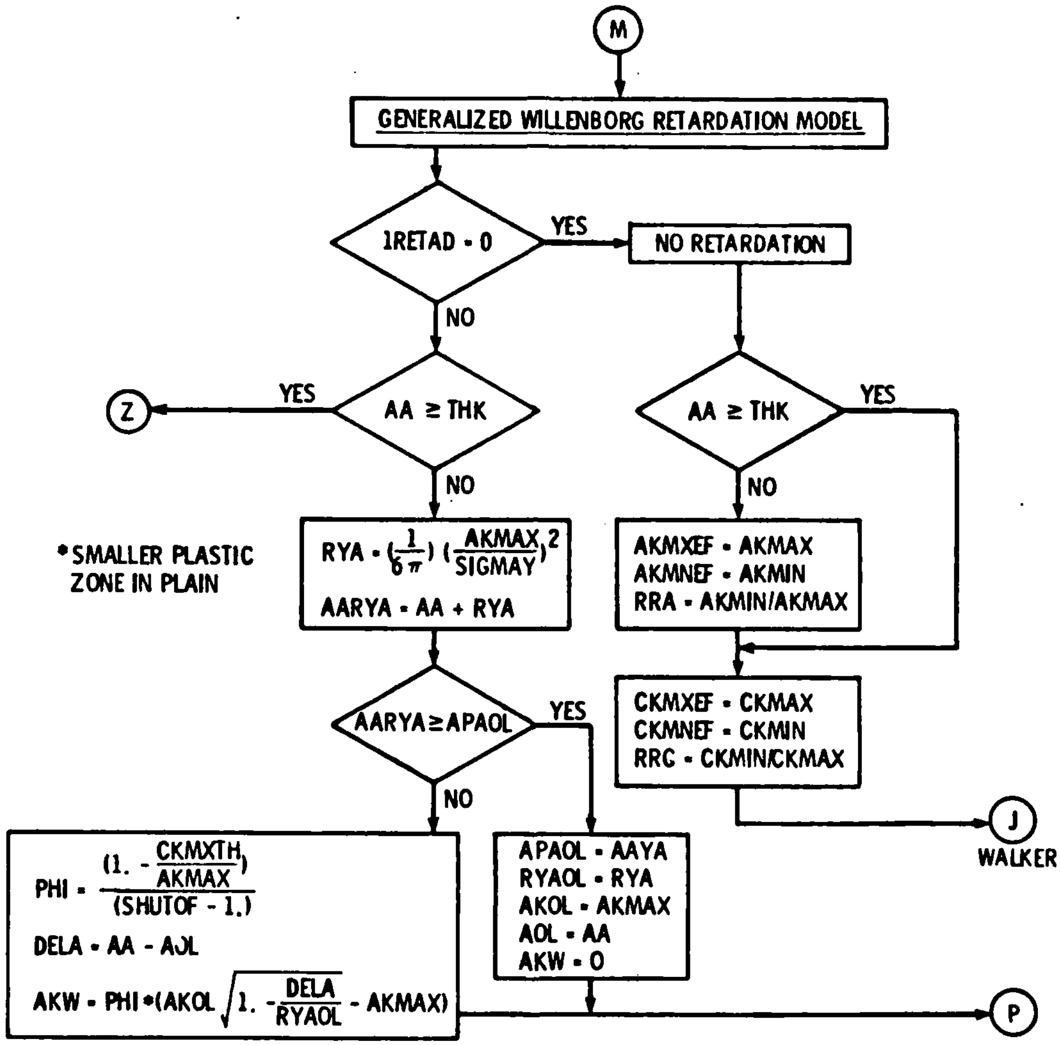
A1, C1, A2, C2, A1NEW, C1NEW, A2NEW, C2NEW, AKMAX1
CKMAX1, AKMAX2, CKMAX2, DA1DF, DC1DF, DA2DF, DC2DF,
SMXS1, SMXS2, BLOK


SUBROUTINE GROW
CYCP = CYC
TCYC = 0.
GOTO (100, 120), NC
110 INITIALIZE FOR NC = 1
120 INITIALIZE FOR NC = 2
COMPUTE STRESS INTENSITY FACTOR
CALL KXXXX(LCK) - BASED ON KKID
GET AK, CK
AKMAX = AK * SMAX
AKMIN = AK * SMIN
CKMAX = CK * SMAX
CKMIN = CK * SMIN
900
I
CHECK INSTABILITY
AKMAXS = AK * SMAXS
CKMAXS = CK * SMAXS
* SMAXS → MAX σ IN SPECTRUM
SMAX → MAX σ IN ONE STEP
K

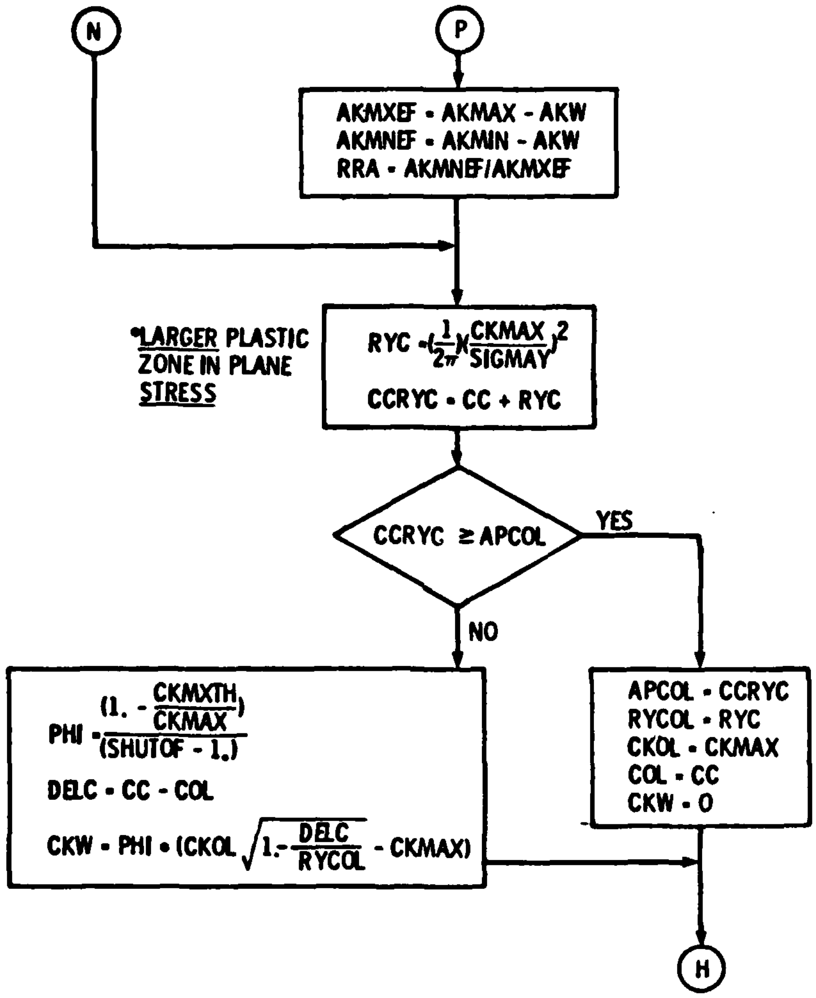

K
AA ≥ THK
YES
NO
AKMAXS < AKJC
YES
NO
UNSTABLE BREAK-THROUGH
OF AA
CKMAXS < CKC
YES
L
NO
UNSTABLE GROWTH OF
CRACK NO. ___ CC
NSTABL = 1
RETURN

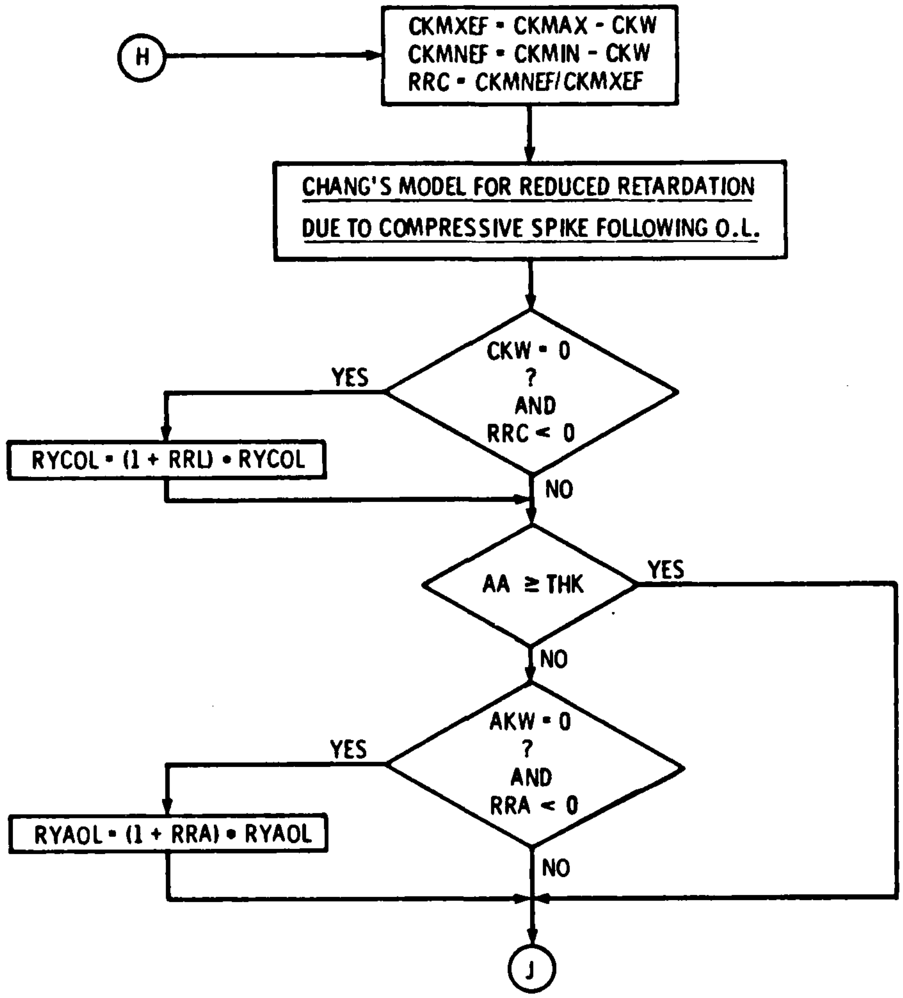


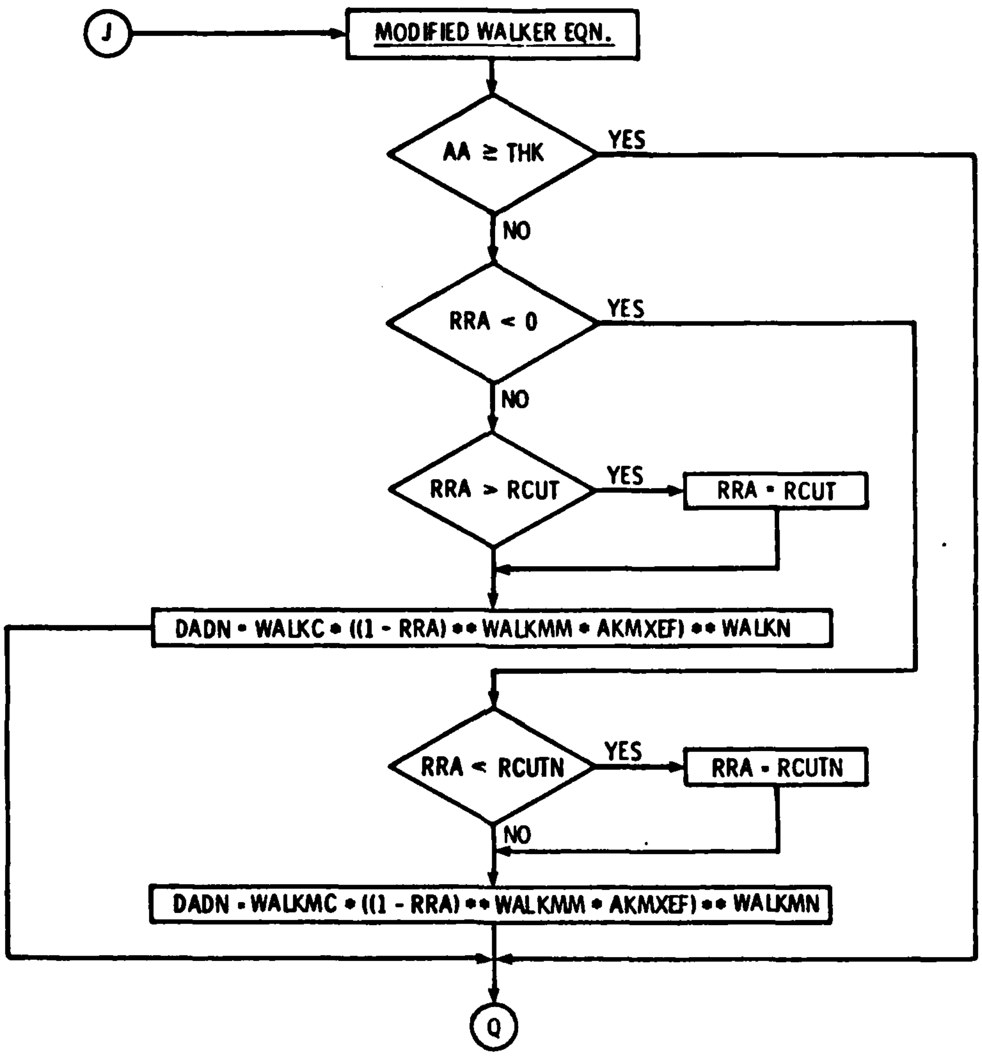
L
COMPARE CRACK LENGTH W/SPECIFIED VALUES
NC = 2
YES
NO
CC < CF1
YES
M
YES
CC < CF2
NO
NO
CRACK NO. 1 HAS REACHED FINAL LENGTH
CRACK NO. 2 HAS REACHED FINAL LENGTH
IFINAL = 1
IFINAL = 2
RETURN
RETURN



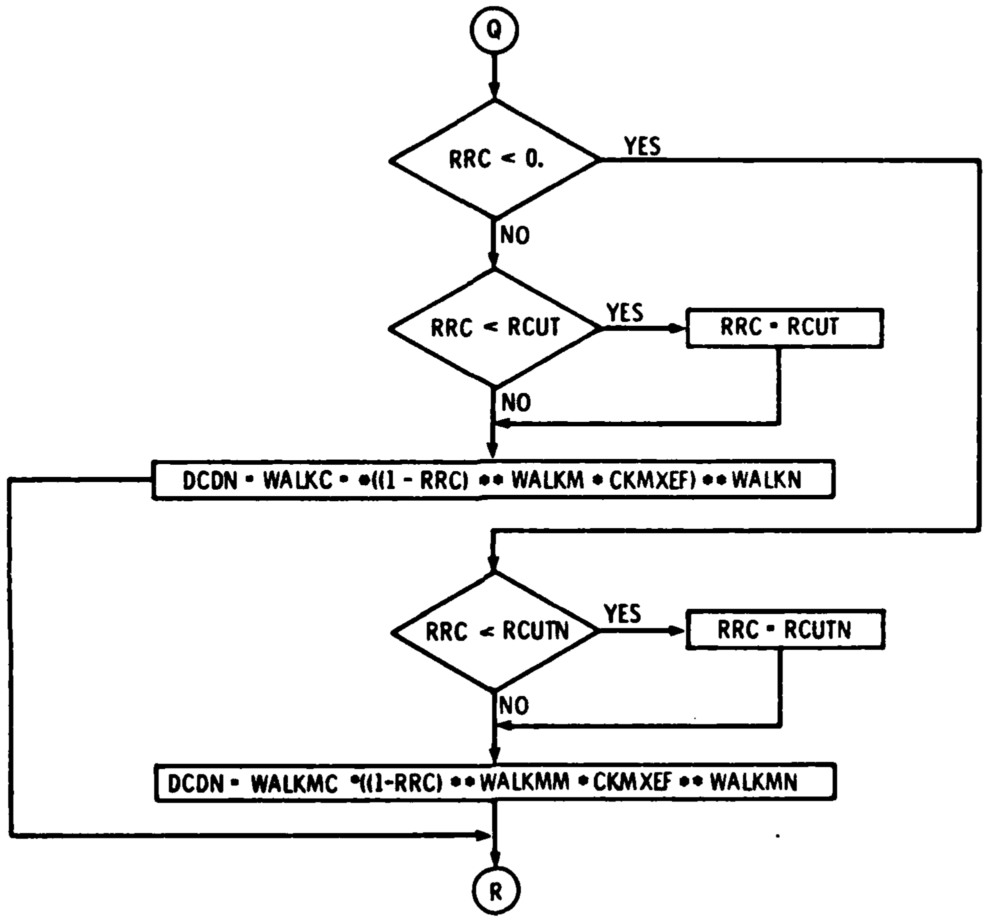
M
GENERALIZED WILLENBORG RETARDATION MODEL
IRETAD = 0
YES
NO RETARDATION
NO
AA ≥ THK
YES
Z
NO
*SMALLER PLASTIC
ZONE IN PLAIN
RYA = (1/6π) (AKMAX/SIGMAY)^2
AARYA = AA + RYA
AA ≥ THK
YES
NO
AKMXEF = AKMAX
AKMNEF = AKMIN
RRA = AKMIN/AKMAX
CKMXEF = CKMAX
CKMNEF = CKMIN
RRC = CKMIN/CKMAX
J
WALKER
AARYA≥APAOL
YES
NO
PHI = (1. - CKMXTH/AKMAX)/(SHUTOF - 1.)
DELA = AA - AOL
AKW = PHI*(AKOL √(1. - DELA/RYAOL) - AKMAX)
APAOL = AAYA
RYAOL = RYA
AKOL = AKMAX
AOL = AA
AKW = 0
P


N
P
AKMXEF = AKMAX - AKW
AKMNEF = AKMIN - AKW
RRA = AKMNEF/AKMXEF
*LARGER PLASTIC ZONE IN PLANE STRESS
RYC = (1/2π)(CKMAX/SIGMAY)^2
CCRYC = CC + RYC
CCRYC ≥ APCOL
YES
NO
PHI = (1. - CKMXTH/CKMAX)/(SHUTOF - 1.)
DELC = CC - COL
CKW = PHI * (CKOL √(1.- DELC/RYCOL) - CKMAX)
APCOL = CCRYC
RYCOL = RYC
CKOL = CKMAX
COL = CC
CKW = 0
H

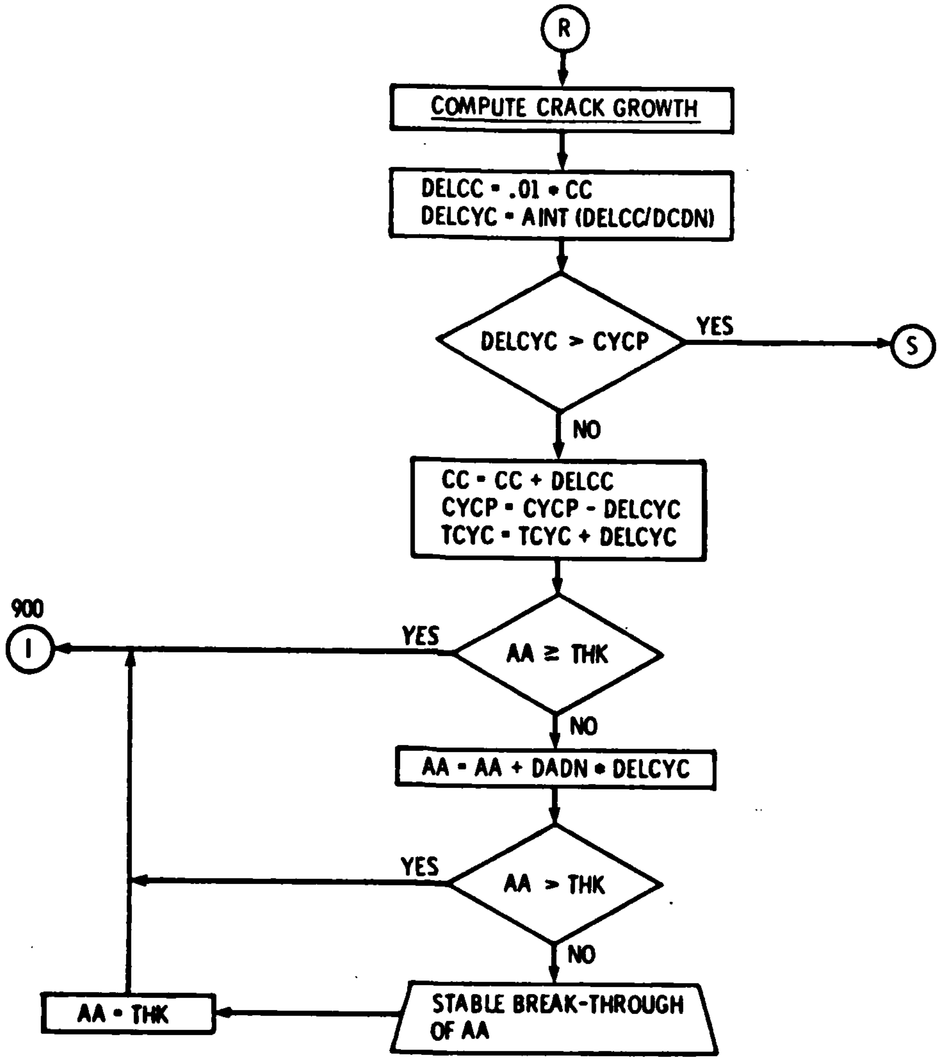

H
CKMXEF = CKMAX - CKW
CKMNEF = CKMIN - CKW
RRC = CKMNEF/CKMXEF
CHANG'S MODEL FOR REDUCED RETARDATION DUE TO COMPRESSIVE SPIKE FOLLOWING O.L.
CKW = 0 ? AND RRC < 0
YES
NO
RYCOL = (1 + RRL) • RYCOL
AA ≥ THK
YES
NO
AKW = 0 ? AND RRA < 0
YES
NO
RYAOL = (1 + RRA) • RYAOL
J

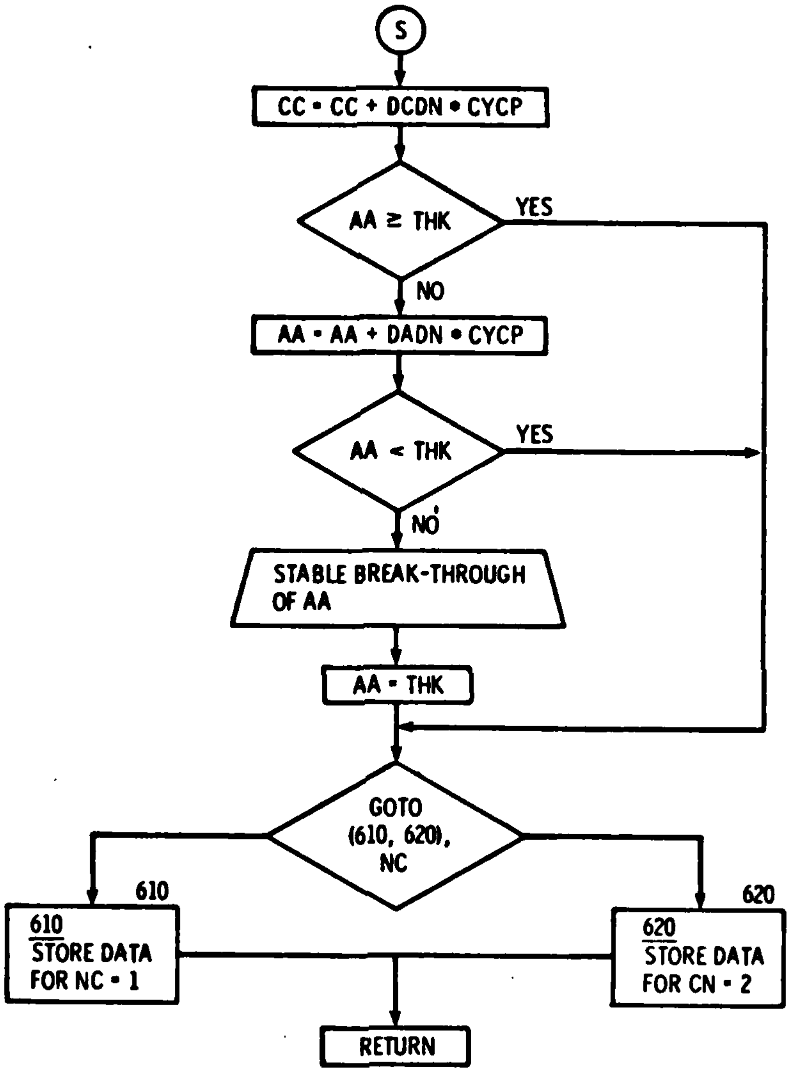


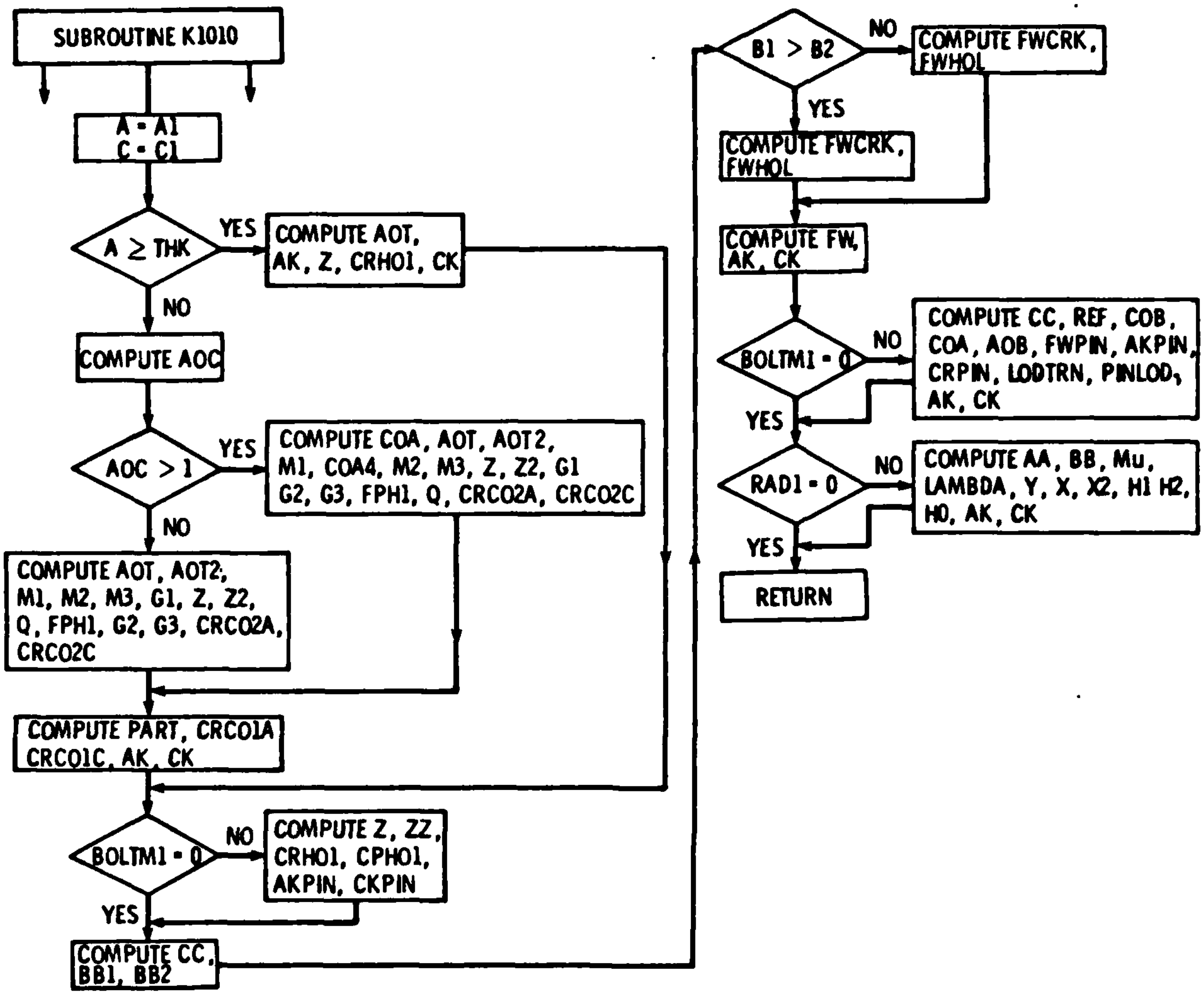
J
MODIFIED WALKER EQN.
AA ≥ THK
YES
NO
RRA < 0
YES
NO
RRA > RCUT
YES
RRA = RCUT
DADN = WALKC * ((1 - RRA) ** WALKMM * AKMXEF) ** WALKN
RRA < RCUTN
YES
RRA = RCUTN
NO
DADN = WALKMC * ((1 - RRA) ** WALKMM * AKMXEF) ** WALKMN
Q

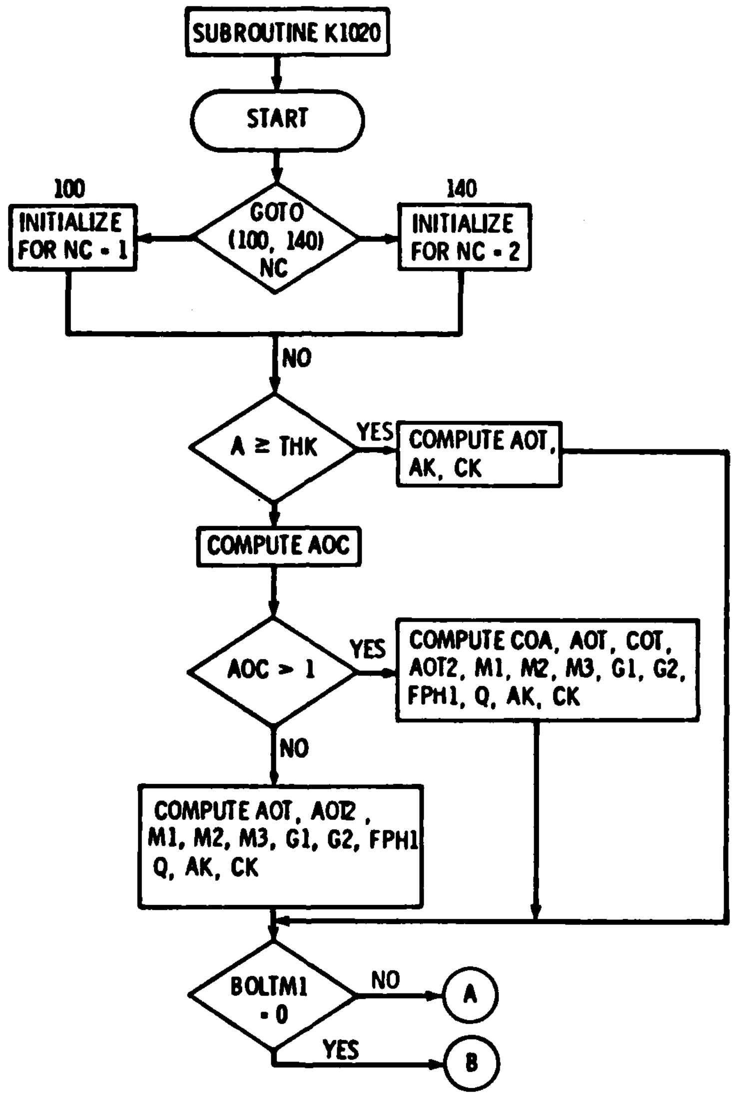


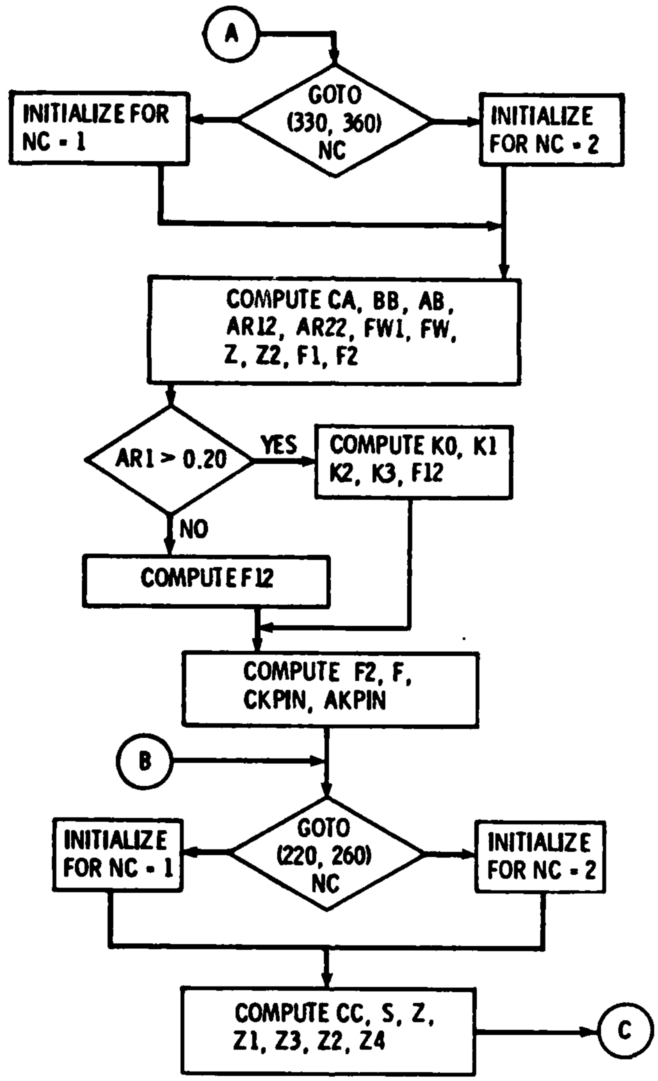
Q
RRC < 0.
YES
NO
RRC < RCUT
YES
RRC = RCUT
NO
DCDN = WALKC * ((1 - RRC) ** WALKM * CKMXEF) ** WALKN
RRC < RCUTN
YES
RRC = RCUTN
NO
DCDN = WALKMC *((1-RRC) ** WALKMM * CKMXEF ** WALKMN
R


R
COMPUTE CRACK GROWTH
DELCC = .01 * CC
DELCYC = AINT (DELCC/DCDN)
DELCYC > CYCP
YES
S
NO
CC = CC + DELCC
CYCP = CYCP - DELCYC
TCYC = TCYC + DELCYC
900
I
YES
AA ≥ THK
NO
AA = AA + DADN * DELCYC
YES
AA > THK
NO
STABLE BREAK-THROUGH OF AA
AA = THK

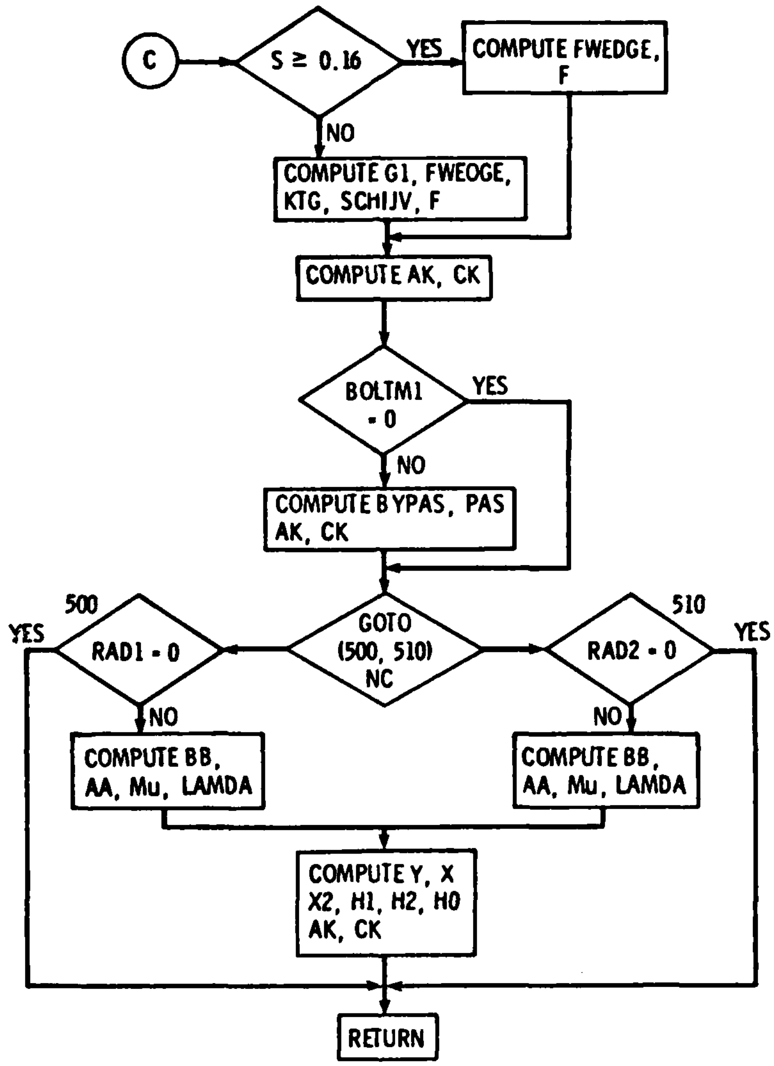

S
CC = CC + DCDN * CYCP
AA ≥ THK
YES
NO
AA = AA + DADN * CYCP
AA < THK
YES
NO
STABLE BREAK-THROUGH OF AA
AA = THK
GOTO (610, 620), NC
610
610 STORE DATA FOR NC = 1
620
620 STORE DATA FOR CN = 2
RETURN

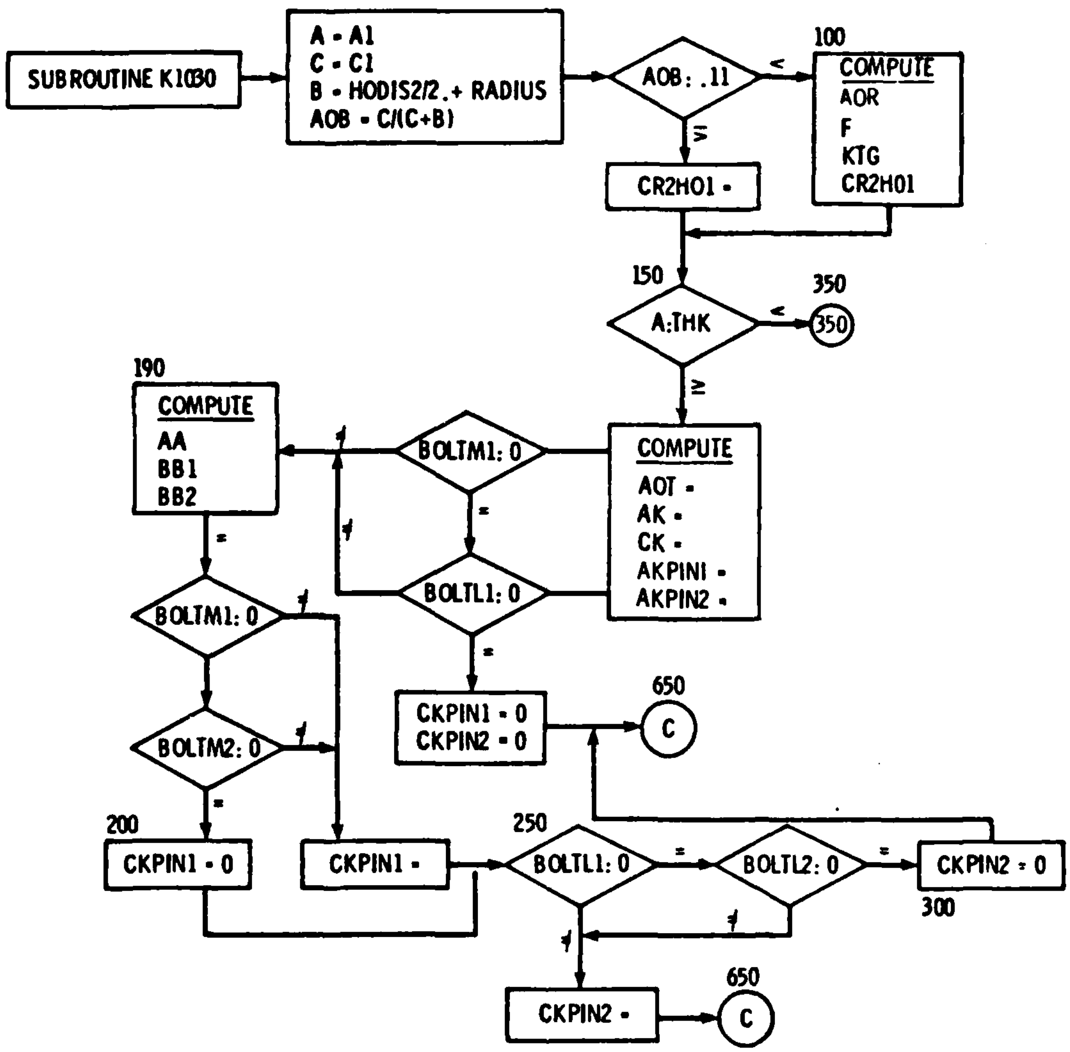

SUBROUTINE K1010
A = A1
C = C1
A ≥ THK
YES
COMPUTE AOT, AK, Z, CRHO1, CK
NO
COMPUTE AOC
AOC > 1
YES
COMPUTE COA, AOT, AOT2, M1, COA4, M2, M3, Z, Z2, G1 G2, G3, FPH1, Q, CRCO2A, CRCO2C
NO
COMPUTE AOT, AOT2, M1, M2, M3, G1, Z, Z2, Q, FPH1, G2, G3, CRCO2A, CRCO2C
COMPUTE PART, CRCO1A CRCO1C, AK, CK
BOLTM1 = 0
NO
COMPUTE Z, ZZ, CRHO1, CPHO1, AKPIN, CKPIN
YES
COMPUTE CC, BB1, BB2
B1 > B2
NO
COMPUTE FWCRK, FWHOL
YES
COMPUTE FWCRK, FWHOL
COMPUTE FW, AK, CK
BOLTM1 = 0
NO
COMPUTE CC, REF, COB, COA, AOB, FWPIN, AKPIN, CRPIN, LODTRN, PINLOD, AK, CK
YES
RAD1 = 0
NO
COMPUTE AA, BB, Mu, LAMBDA, Y, X, X2, H1 H2, H0, AK, CK
YES
RETURN

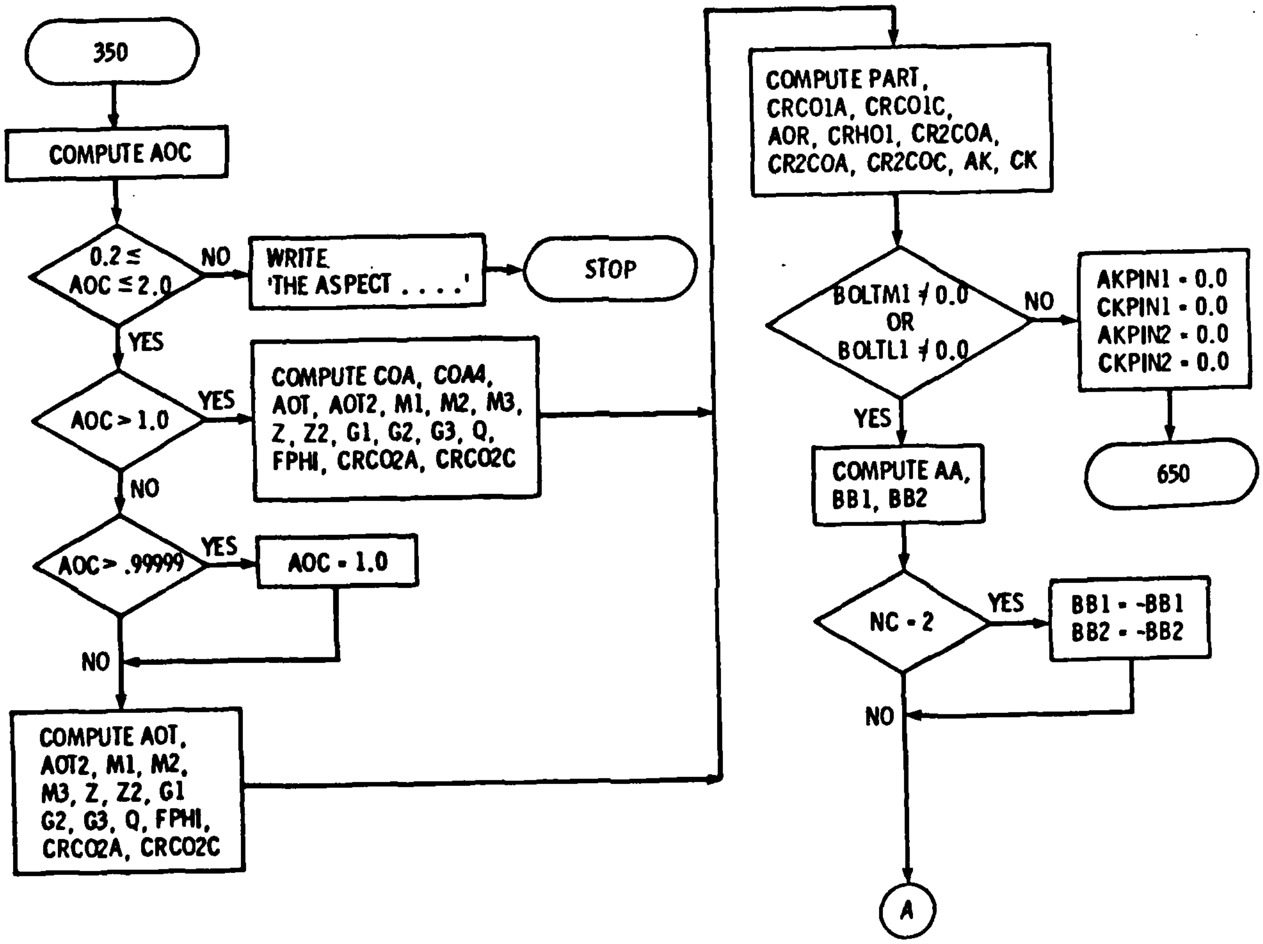

SUBROUTINE K1020
START
100
INITIALIZE FOR NC = 1
GOTO (100, 140) NC
140
INITIALIZE FOR NC = 2
NO
A ≥ THK
YES
COMPUTE AOT, AK, CK
COMPUTE AOC
AOC > 1
YES
COMPUTE COA, AOT, COT, AOT2, M1, M2, M3, G1, G2, FPH1, Q, AK, CK
NO
COMPUTE AOT, AOT2, M1, M2, M3, G1, G2, FPH1 Q, AK, CK
BOLTM1 = 0
NO
A
YES
B

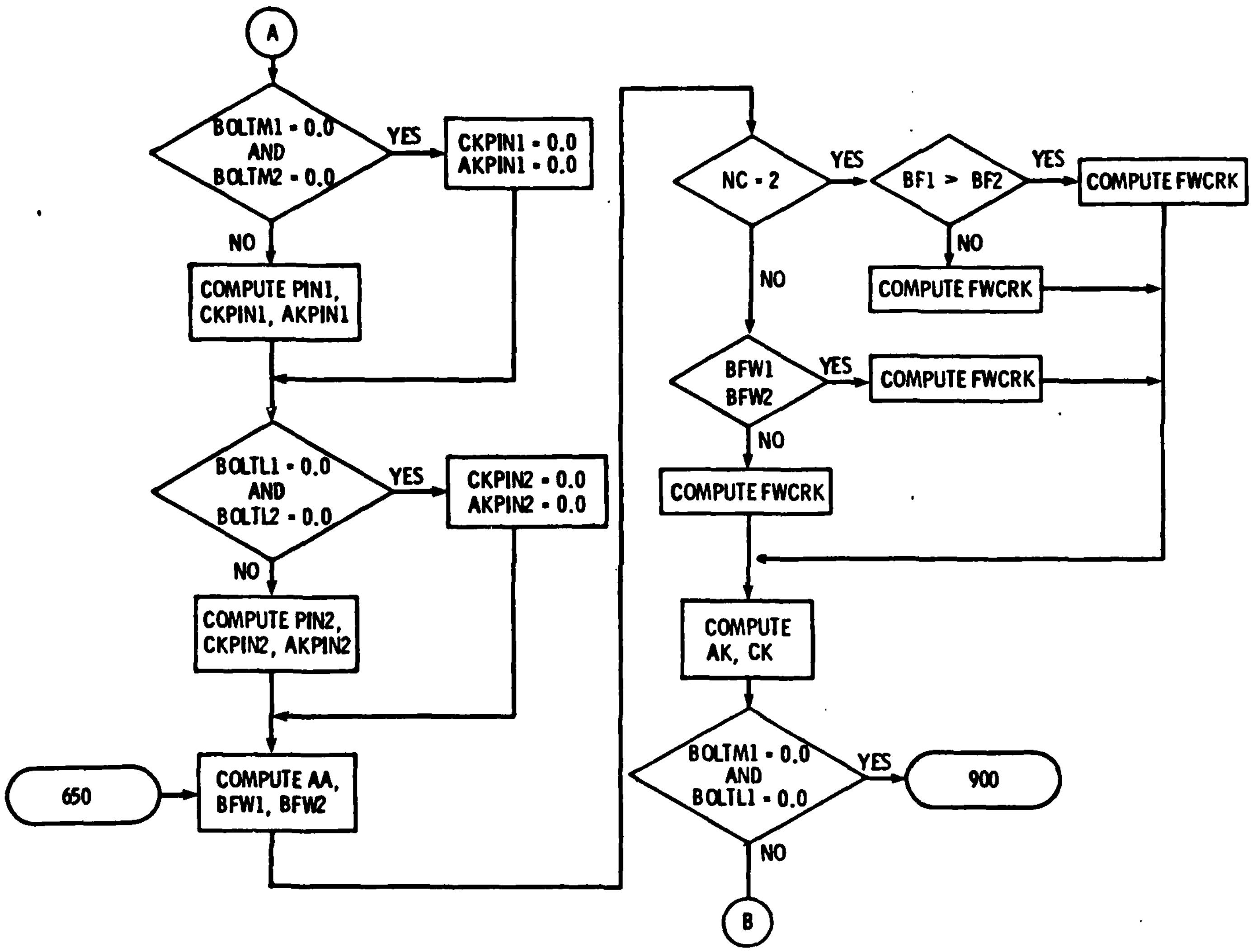


A
GOTO (330, 360) NC
INITIALIZE FOR NC = 1
INITIALIZE FOR NC = 2
COMPUTE CA, BB, AB, AR12, AR22, FW1, FW, Z, Z2, F1, F2
AR1 > 0.20
YES
COMPUTE K0, K1 K2, K3, F12
NO
COMPUTE F12
COMPUTE F2, F, CKPIN, AKPIN
B
GOTO (220, 260) NC
INITIALIZE FOR NC = 1
INITIALIZE FOR NC = 2
COMPUTE CC, S, Z, Z1, Z3, Z2, Z4
C

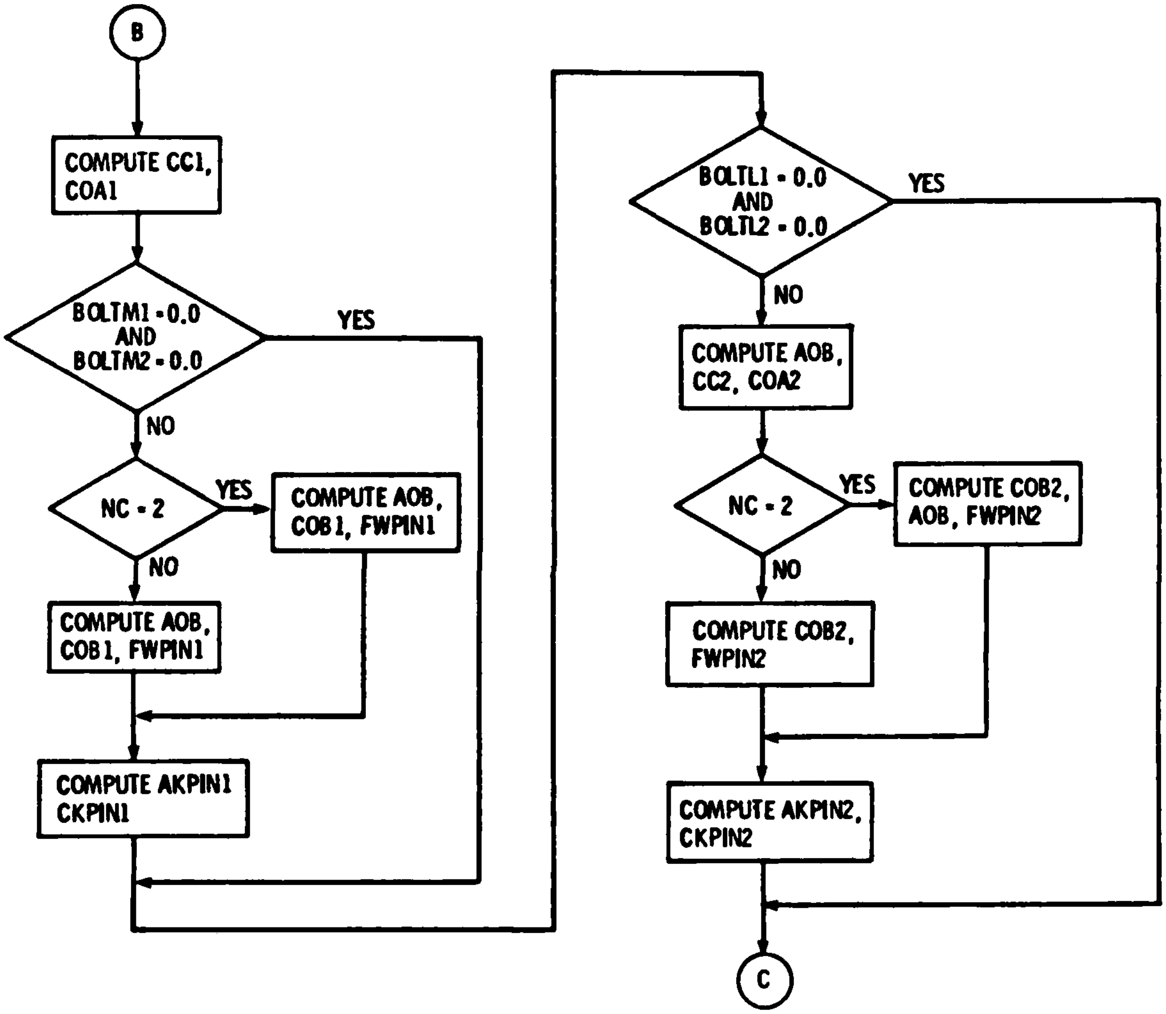

C
S ≥ 0.16
YES
COMPUTE FWEDGE, F
NO
COMPUTE G1, FWEDGE, KTG, SCHIJV, F
COMPUTE AK, CK
BOLTM1 = 0
YES
NO
COMPUTE BYPAS, PAS AK, CK
500
510
GOTO (500, 510) NC
RAD1 = 0
RAD2 = 0
YES
YES
NO
NO
COMPUTE BB, AA, Mu, LAMDA
COMPUTE BB, AA, Mu, LAMDA
COMPUTE Y, X X2, H1, H2, H0 AK, CK
RETURN

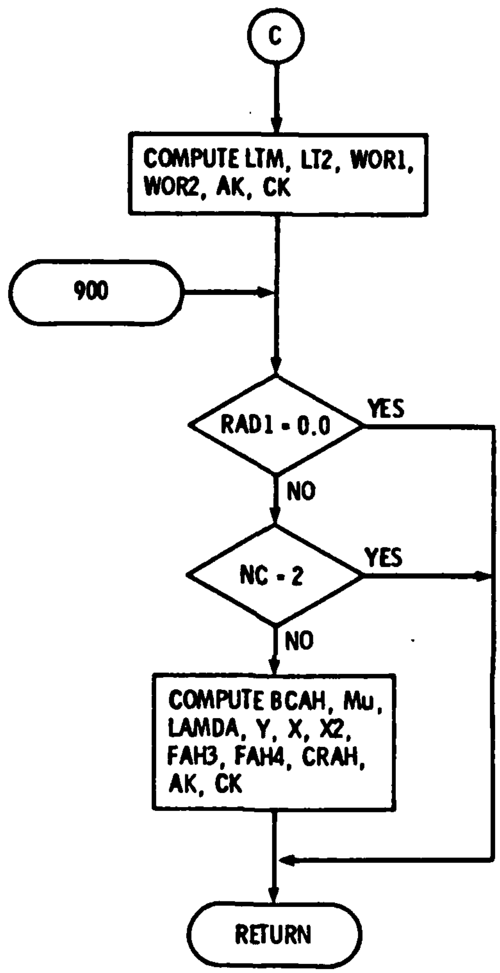

SUBROUTINE K1030
A = A1
C = C1
B = HODIS2/2.+ RADIUS
AOB = C/(C+B)
AOB: .11
100
COMPUTE
AOR
F
KTG
CR2H01
CR2H01 =
150
A:THK
350
190
COMPUTE
AA
BB1
BB2
BOLTM1: 0
COMPUTE
AOT =
AK =
CK =
AKPIN1 =
AKPIN2 =
BOLTL1: 0
BOLTM1: 0
BOLTM2: 0
CKPIN1 = 0
CKPIN2 = 0
650
C
200
CKPIN1 = 0
CKPIN1 =
250
BOLTL1: 0
BOLTL2: 0
CKPIN2 = 0
300
CKPIN2 =
650
C

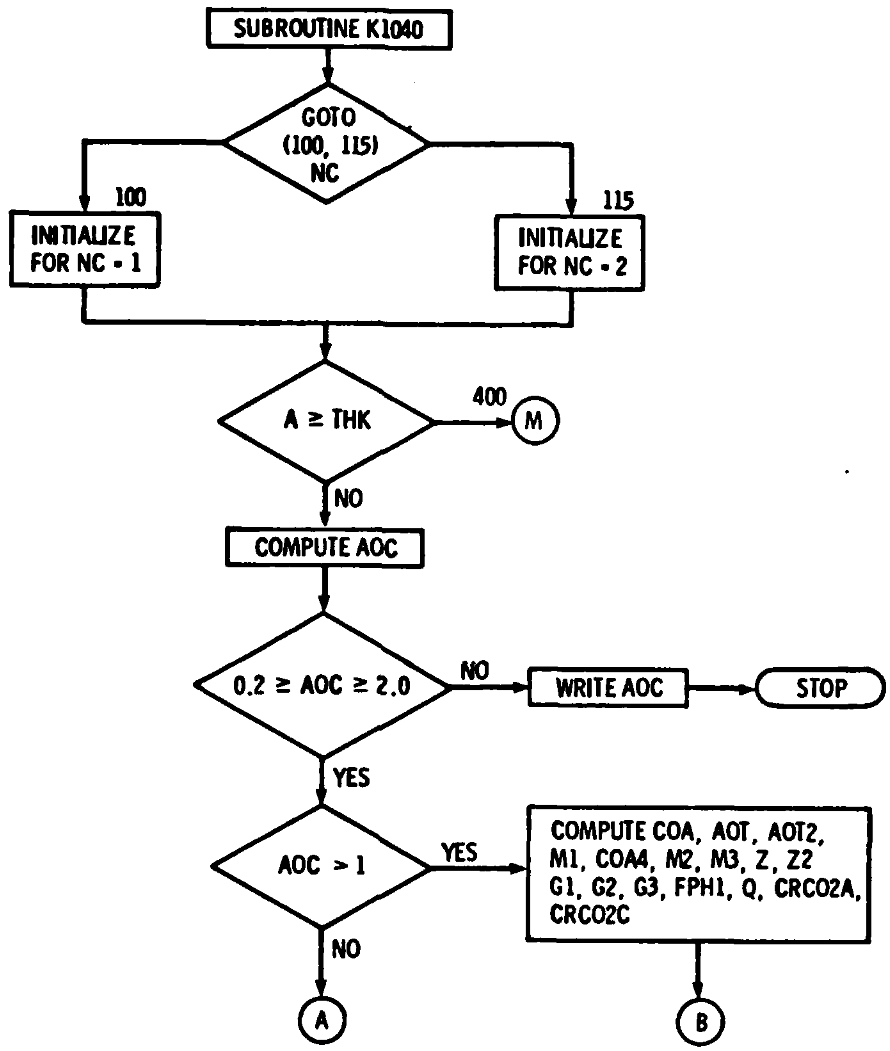

350
COMPUTE AOC
0.2 ≤ AOC ≤ 2.0
NO
WRITE 'THE ASPECT . . . .'
STOP
YES
AOC > 1.0
YES
COMPUTE COA, COA4, AOT, AOT2, M1, M2, M3, Z, Z2, G1, G2, G3, Q, FPHI, CRCO2A, CRCO2C
NO
AOC > .99999
YES
AOC = 1.0
NO
COMPUTE AOT, AOT2, M1, M2, M3, Z, Z2, G1 G2, G3, Q, FPHI, CRCO2A, CRCO2C
COMPUTE PART, CRCO1A, CRCO1C, AOR, CRHO1, CR2COA, CR2COA, CR2COC, AK, CK
BOLTM1 ≠ 0.0 OR BOLTL1 ≠ 0.0
NO
AKPIN1 = 0.0
CKPIN1 = 0.0
AKPIN2 = 0.0
CKPIN2 = 0.0
650
YES
COMPUTE AA, BB1, BB2
NC = 2
YES
BB1 = -BB1
BB2 = -BB2
NO
A

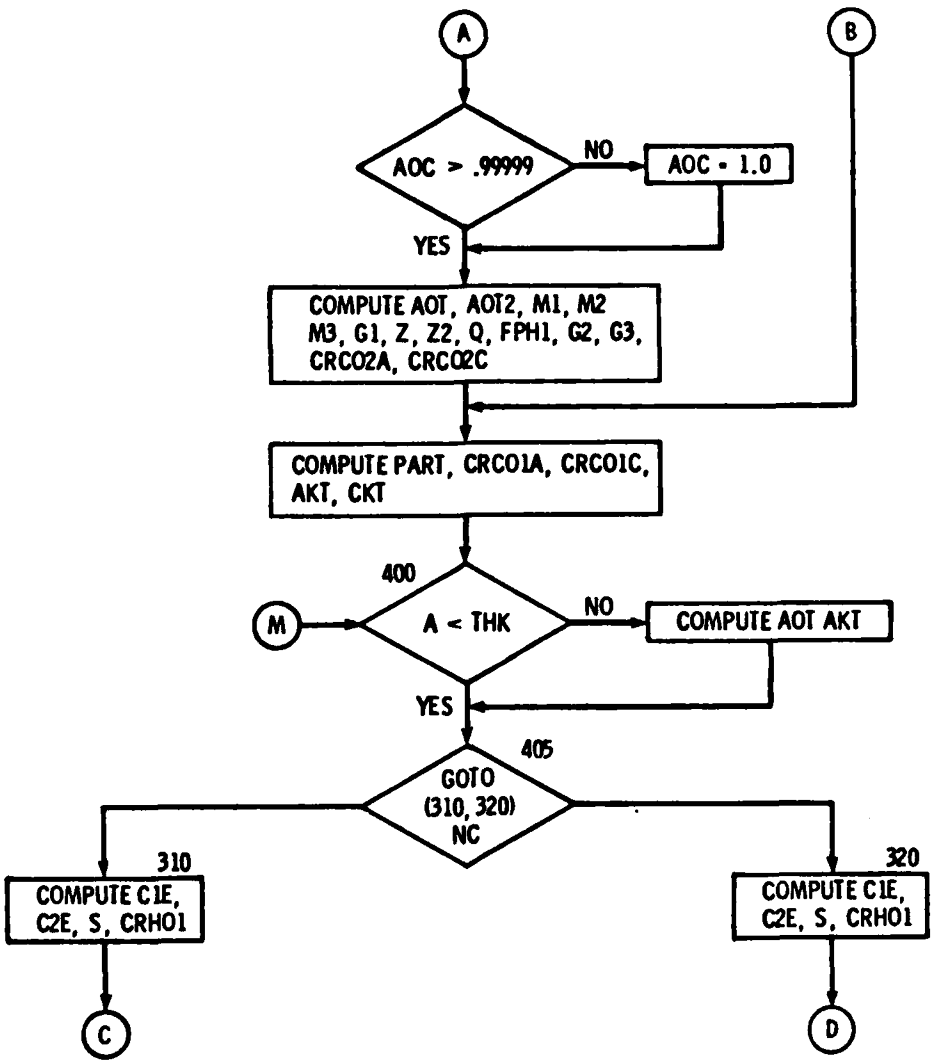


A
BOLTM1 = 0.0
AND
BOLTM2 = 0.0
YES
CKPIN1 = 0.0
AKPIN1 = 0.0
NO
COMPUTE PIN1,
CKPIN1, AKPIN1
BOLTL1 = 0.0
AND
BOLTL2 = 0.0
YES
CKPIN2 = 0.0
AKPIN2 = 0.0
NO
COMPUTE PIN2,
CKPIN2, AKPIN2
650
COMPUTE AA,
BFW1, BFW2
NC = 2
YES
BF1 > BF2
YES
COMPUTE FWCRK
NO
COMPUTE FWCRK
NO
BFW1
BFW2
YES
COMPUTE FWCRK
NO
COMPUTE FWCRK
COMPUTE
AK, CK
BOLTM1 = 0.0
AND
BOLTL1 = 0.0
YES
900
NO
B

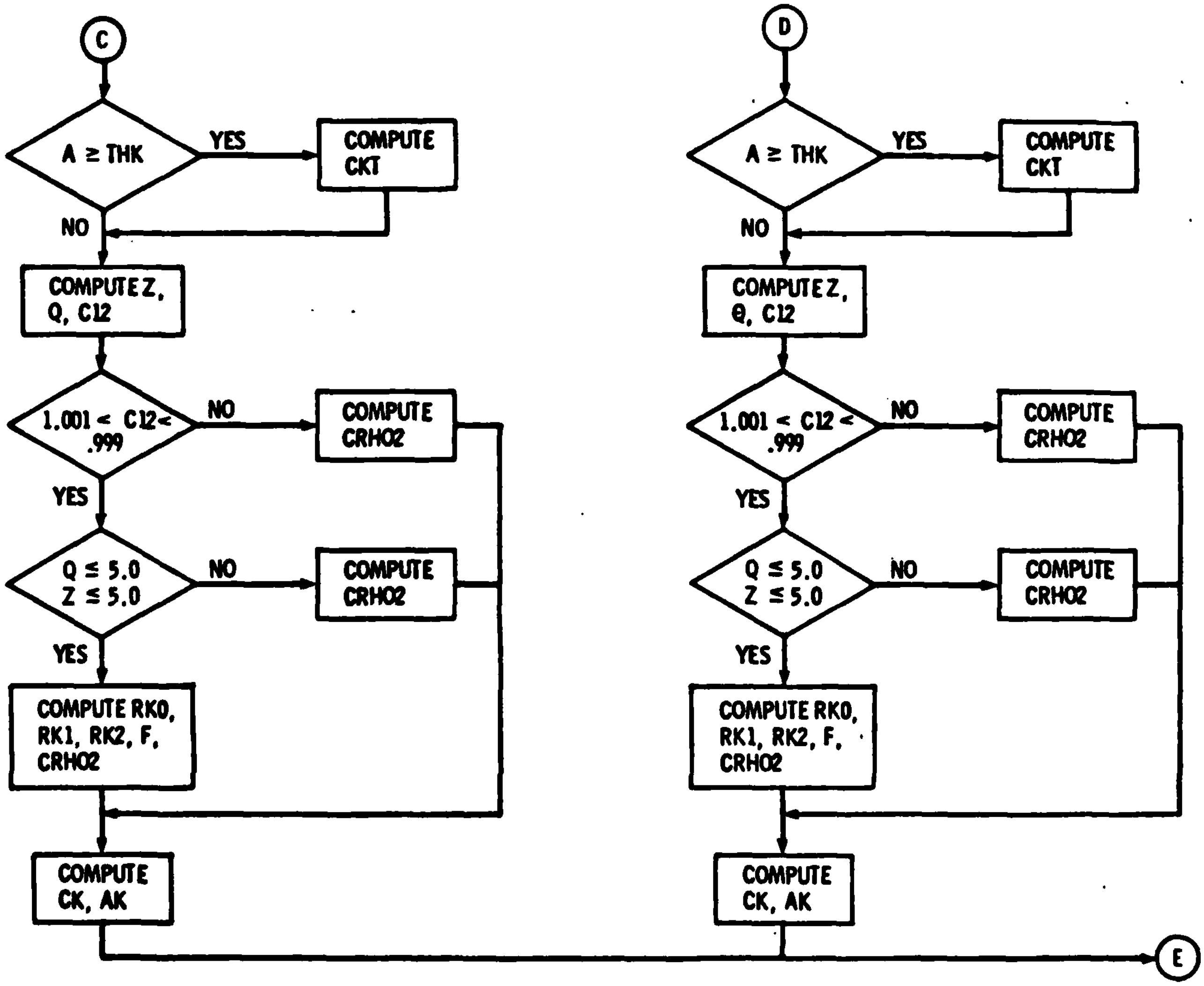

B
COMPUTE CC1, COA1
BOLTM1 = 0.0 AND BOLTM2 = 0.0
YES
NO
NC = 2
YES
COMPUTE AOB, COB1, FWPIN1
NO
COMPUTE AOB, COB1, FWPIN1
COMPUTE AKPIN1 CKPIN1
BOLTL1 = 0.0 AND BOLTL2 = 0.0
YES
NO
COMPUTE AOB, CC2, COA2
NC = 2
YES
COMPUTE COB2, AOB, FWPIN2
NO
COMPUTE COB2, FWPIN2
COMPUTE AKPIN2, CKPIN2
C

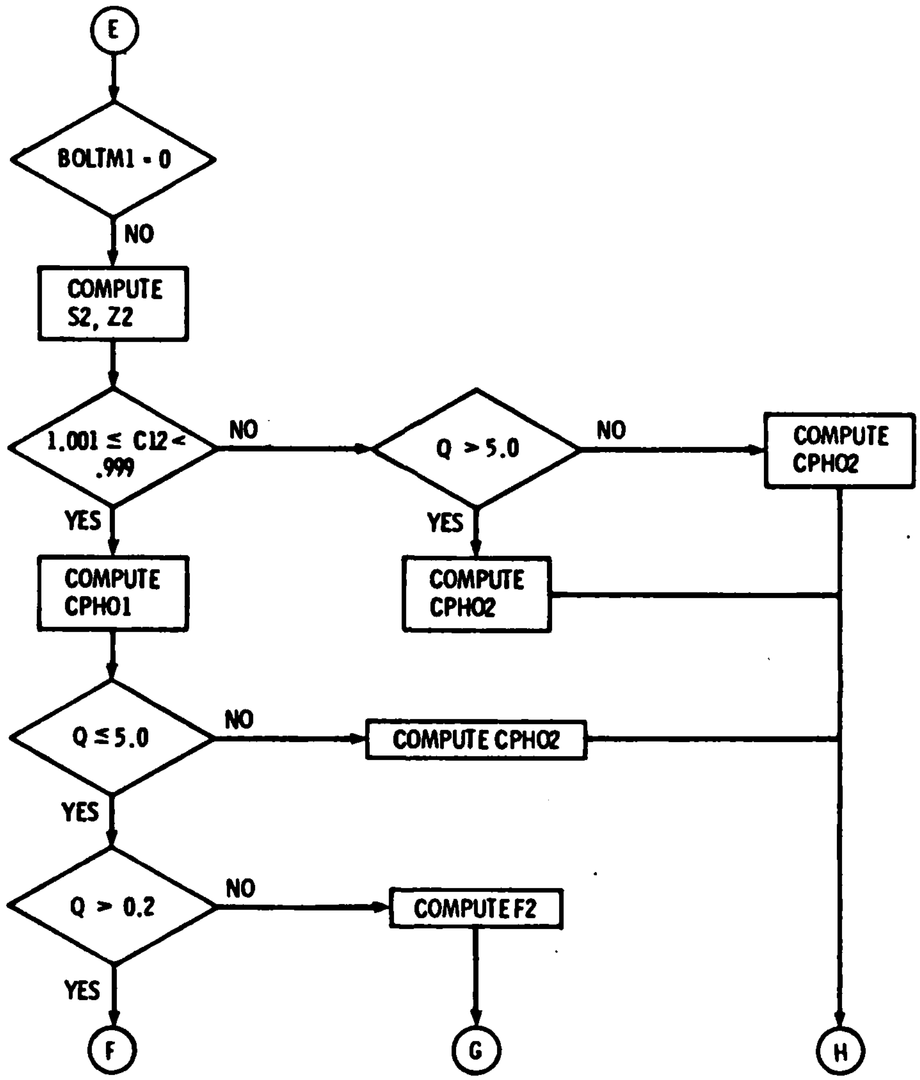

C
COMPUTE LTM, LT2, WOR1, WOR2, AK, CK
900
RAD1 = 0.0
YES
NO
NC = 2
YES
NO
COMPUTE BCAH, Mu, LAMDA, Y, X, X2, FAH3, FAH4, CRAH, AK, CK
RETURN

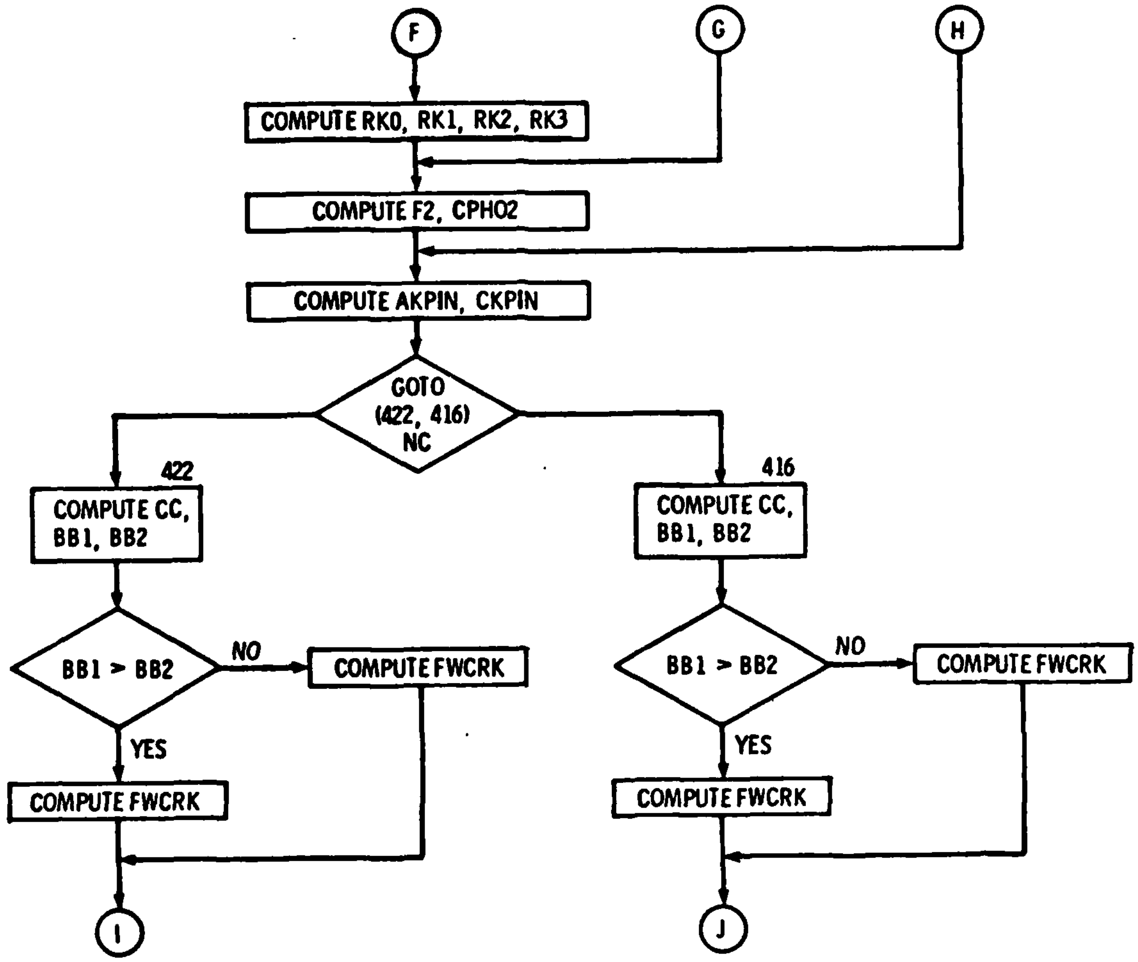

SUBROUTINE K1040
GOTO (100, 115) NC
100
INITIALIZE FOR NC = 1
115
INITIALIZE FOR NC = 2
A ≥ THK
400
M
NO
COMPUTE AOC
0.2 ≥ AOC ≥ 2.0
NO
WRITE AOC
STOP
YES
AOC > 1
YES
COMPUTE COA, AOT, AOT2, M1, COA4, M2, M3, Z, Z2 G1, G2, G3, FPH1, Q, CRCO2A, CRCO2C
NO
A
B

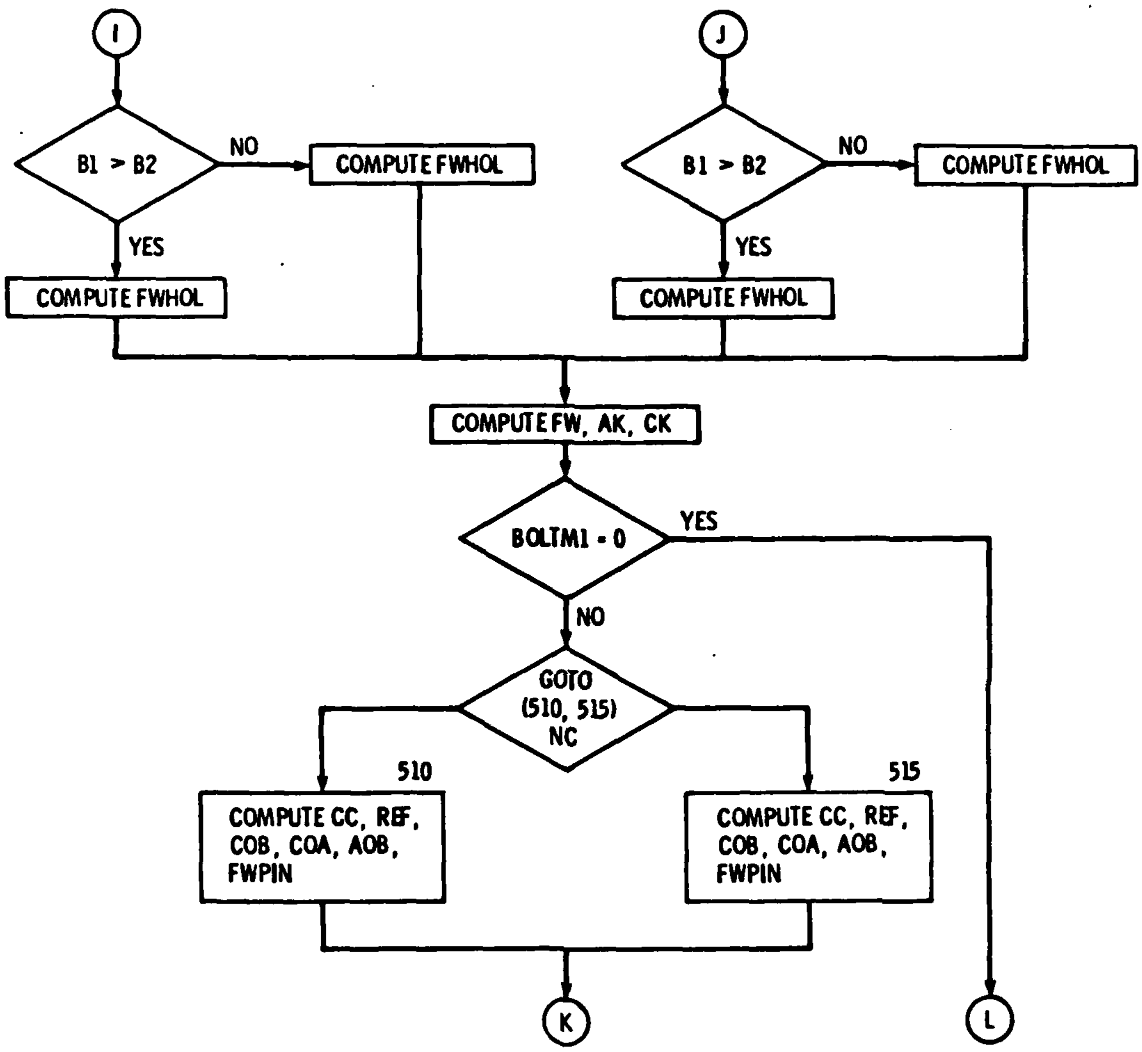


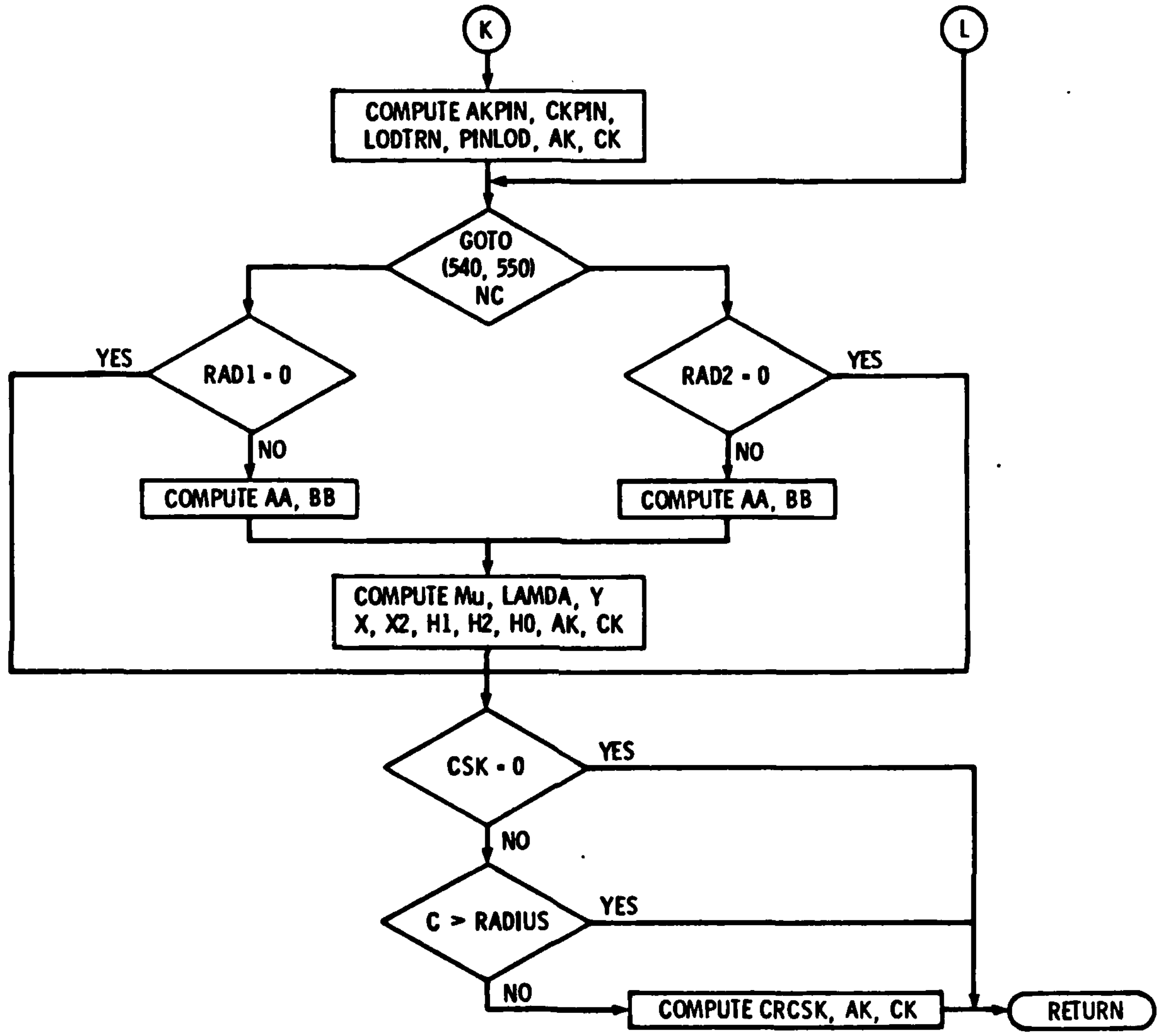
A
B
AOC > .99999
NO
AOC = 1.0
YES
COMPUTE AOT, AOT2, M1, M2
M3, G1, Z, Z2, Q, FPH1, G2, G3,
CRCO2A, CRCO2C
COMPUTE PART, CRCO1A, CRCO1C,
AKT, CKT
400
M
A < THK
NO
COMPUTE AOT AKT
YES
405
GOTO
(310, 320)
NC
310
COMPUTE C1E,
C2E, S, CRHO1
320
COMPUTE C1E,
C2E, S, CRHO1
C
D

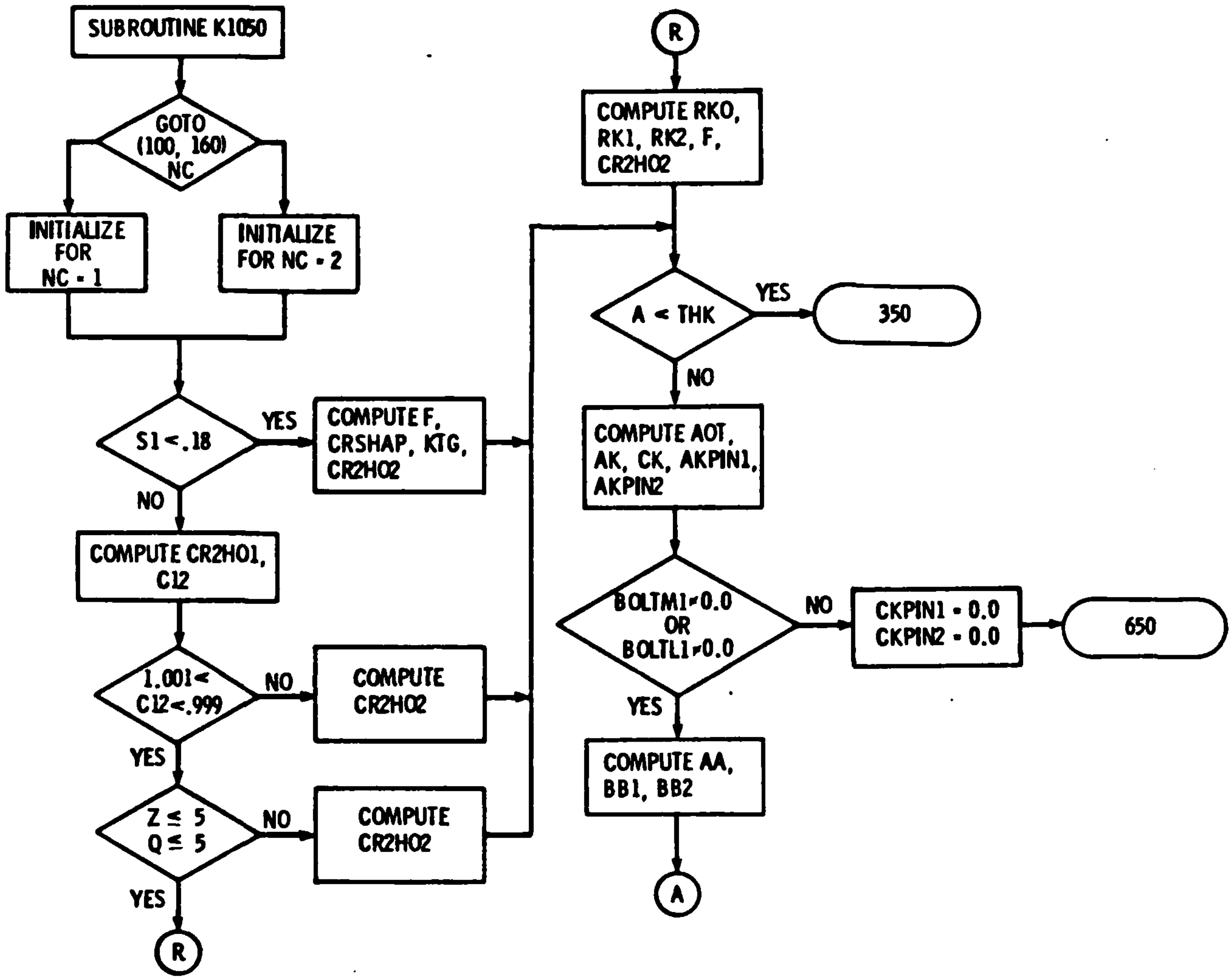

C
A ≥ THK
YES
COMPUTE CKT
NO
COMPUTE Z, Q, C12
1.001 < C12 < .999
NO
COMPUTE CRHO2
YES
Q ≤ 5.0 Z ≤ 5.0
NO
COMPUTE CRHO2
YES
COMPUTE RK0, RK1, RK2, F, CRHO2
COMPUTE CK, AK
D
A ≥ THK
YES
COMPUTE CKT
NO
COMPUTE Z, Q, C12
1.001 < C12 < .999
NO
COMPUTE CRHO2
YES
Q ≤ 5.0 Z ≤ 5.0
NO
COMPUTE CRHO2
YES
COMPUTE RK0, RK1, RK2, F, CRHO2
COMPUTE CK, AK
E

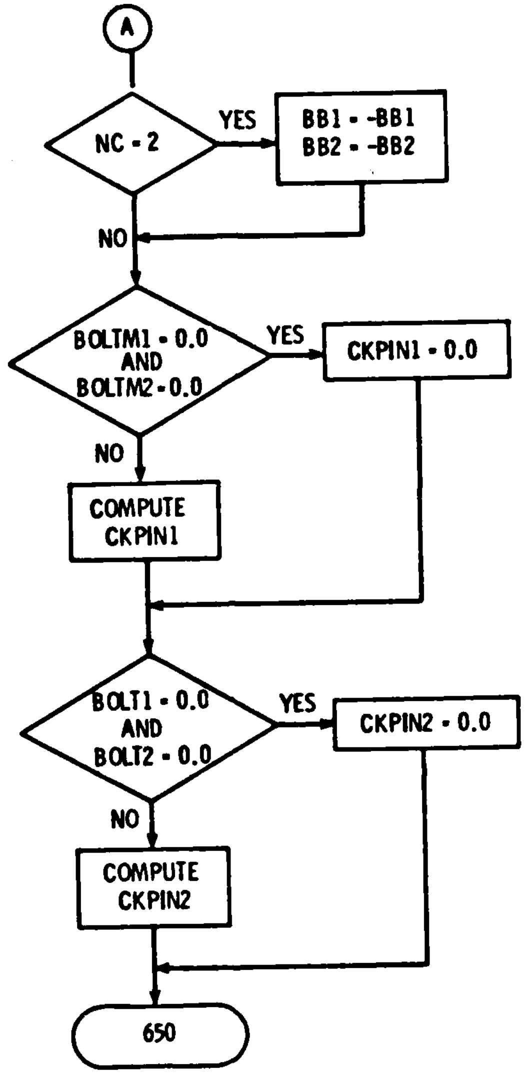

E
BOLTM1 = 0
NO
COMPUTE S2, Z2
1.001 ≤ C12 < .999
NO
Q > 5.0
NO
COMPUTE CPHO2
YES
COMPUTE CPHO1
YES
COMPUTE CPHO2
Q ≤ 5.0
NO
COMPUTE CPHO2
YES
Q > 0.2
NO
COMPUTE F2
YES
F
G
H

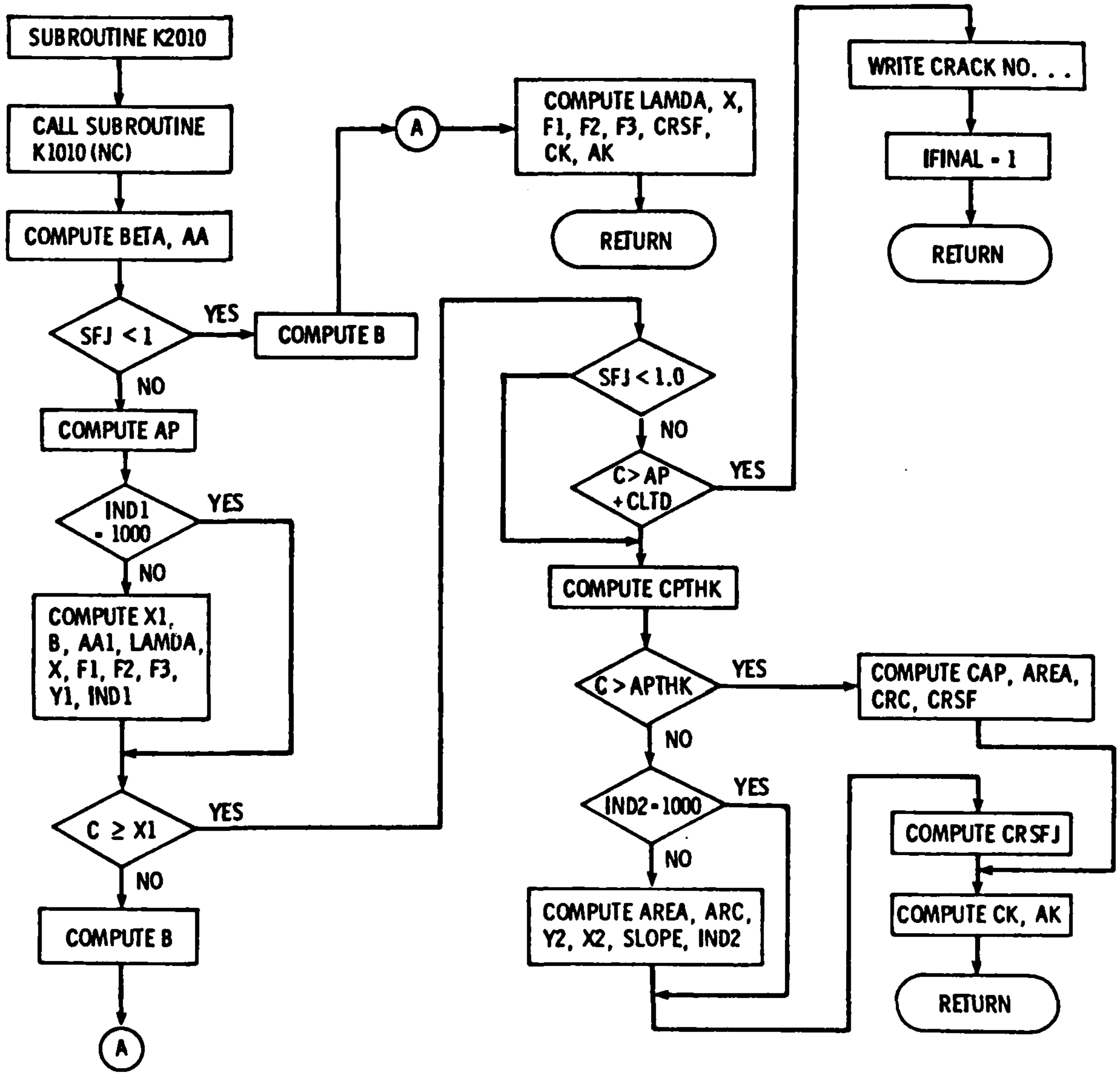

F
G
H
COMPUTE RK0, RK1, RK2, RK3
COMPUTE F2, CPHO2
COMPUTE AKPIN, CKPIN
GOTO
(422, 416)
NC
422
COMPUTE CC,
BB1, BB2
BB1 > BB2
NO
COMPUTE FWCRK
YES
COMPUTE FWCRK
I
416
COMPUTE CC,
BB1, BB2
BB1 > BB2
NO
COMPUTE FWCRK
YES
COMPUTE FWCRK
J


I
J
B1 > B2
NO
YES
COMPUTE FWHOL
COMPUTE FWHOL
B1 > B2
NO
YES
COMPUTE FWHOL
COMPUTE FWHOL
COMPUTE FW, AK, CK
BOLTM1 = 0
YES
NO
GOTO (510, 515) NC
510
515
COMPUTE CC, REF, COB, COA, AOB, FWPIN
COMPUTE CC, REF, COB, COA, AOB, FWPIN
K
L

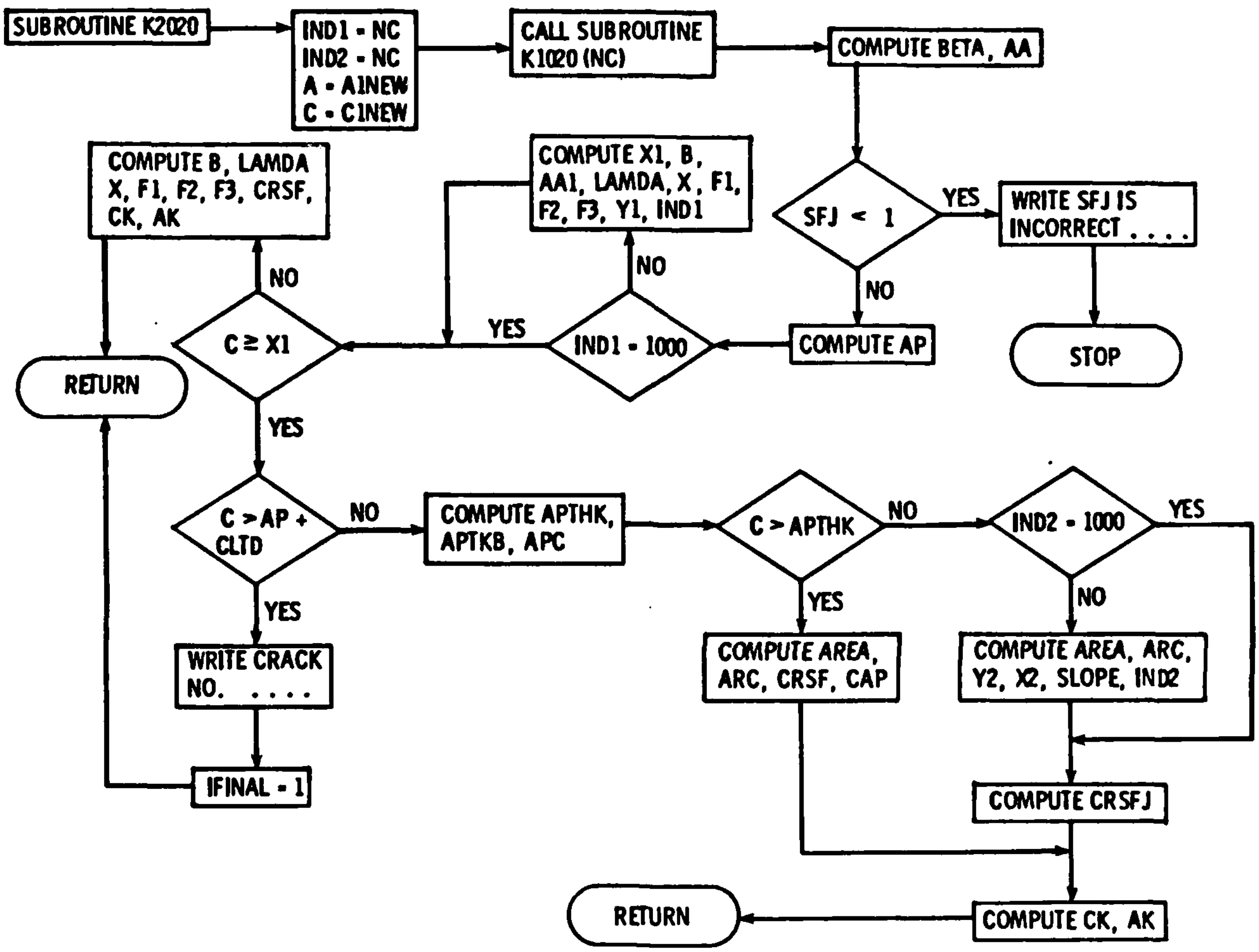

K
L
COMPUTE AKPIN, CKPIN, LODTRN, PINLOD, AK, CK
GOTO (540, 550) NC
RAD1 = 0
YES
NO
COMPUTE AA, BB
RAD2 = 0
YES
NO
COMPUTE AA, BB
COMPUTE Mu, LAMDA, Y X, X2, H1, H2, H0, AK, CK
CSK = 0
YES
NO
C > RADIUS
YES
NO
COMPUTE CRCSK, AK, CK
RETURN

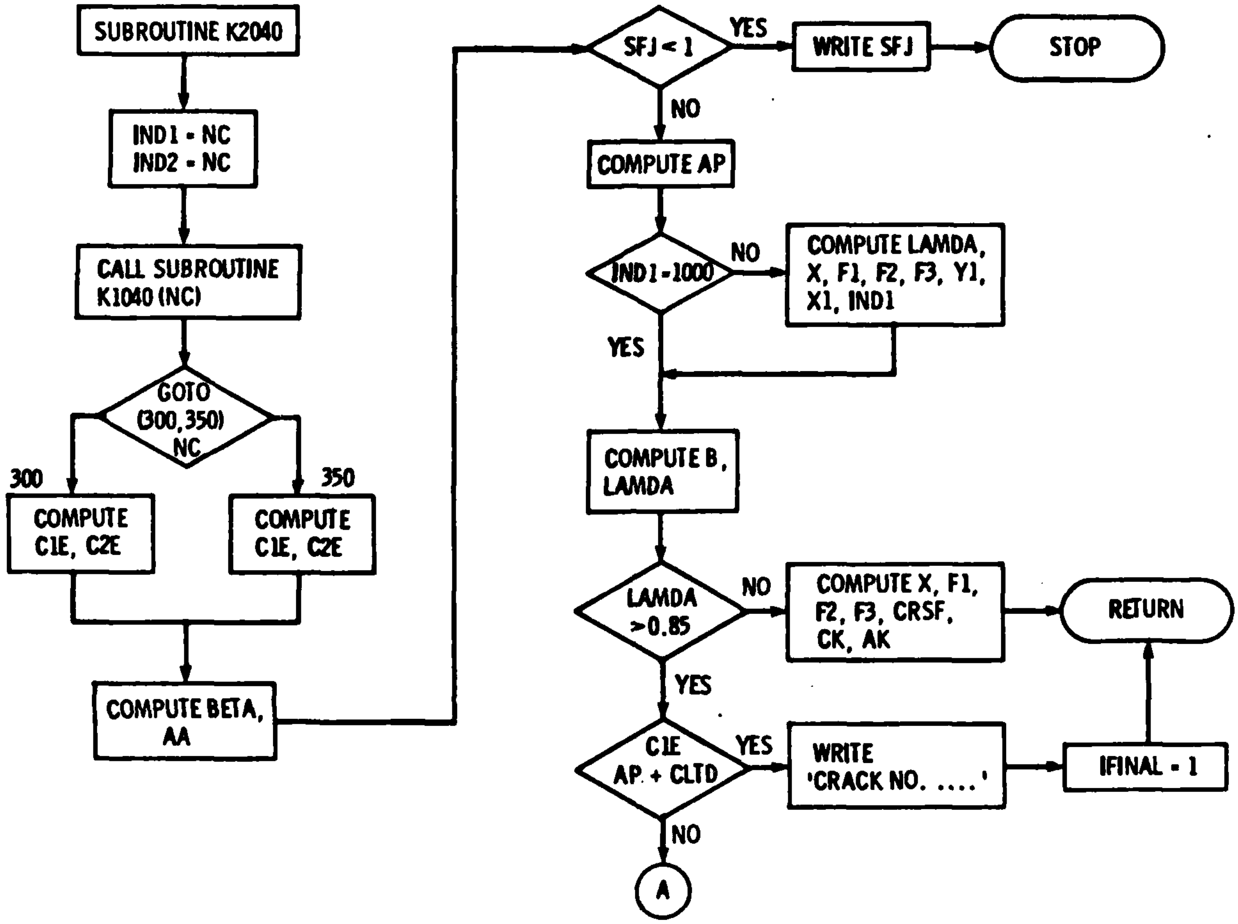

SUBROUTINE K1050
GOTO (100, 160) NC
INITIALIZE FOR NC = 1
INITIALIZE FOR NC = 2
S1 < .18
YES
COMPUTE F, CRSHAP, KTG, CR2HO2
NO
COMPUTE CR2HO1, C12
1.001 < C12 < .999
NO
COMPUTE CR2HO2
YES
Z ≤ 5
Q ≤ 5
NO
COMPUTE CR2HO2
YES
R
R
COMPUTE RKO, RK1, RK2, F, CR2HO2
A < THK
YES
350
NO
COMPUTE AOT, AK, CK, AKPIN1, AKPIN2
BOLTM1≠0.0 OR BOLTL1≠0.0
NO
CKPIN1 = 0.0
CKPIN2 = 0.0
650
YES
COMPUTE AA, BB1, BB2
A

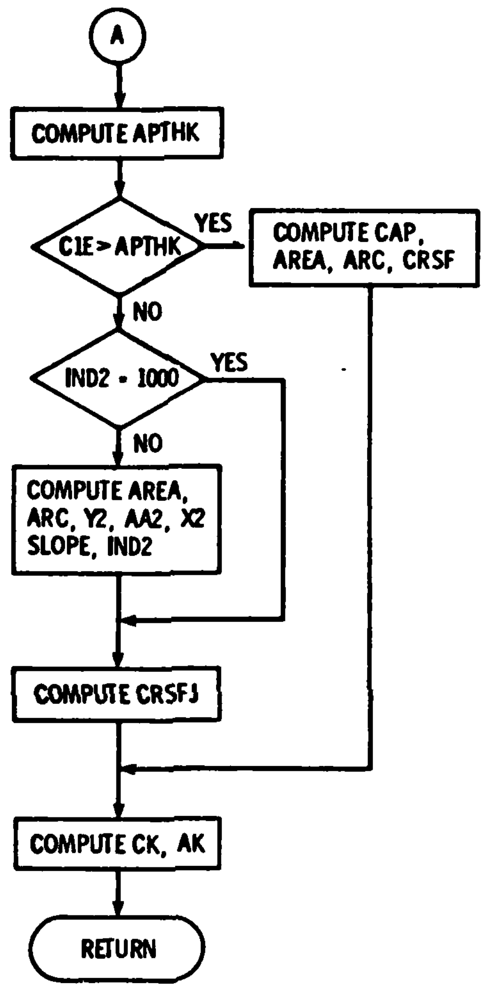

A
NC = 2
YES
BB1 = -BB1
BB2 = -BB2
NO
BOLTM1 = 0.0
AND
BOLTM2 = 0.0
YES
CKPIN1 = 0.0
NO
COMPUTE
CKPIN1
BOLT1 = 0.0
AND
BOLT2 = 0.0
YES
CKPIN2 = 0.0
NO
COMPUTE
CKPIN2
650

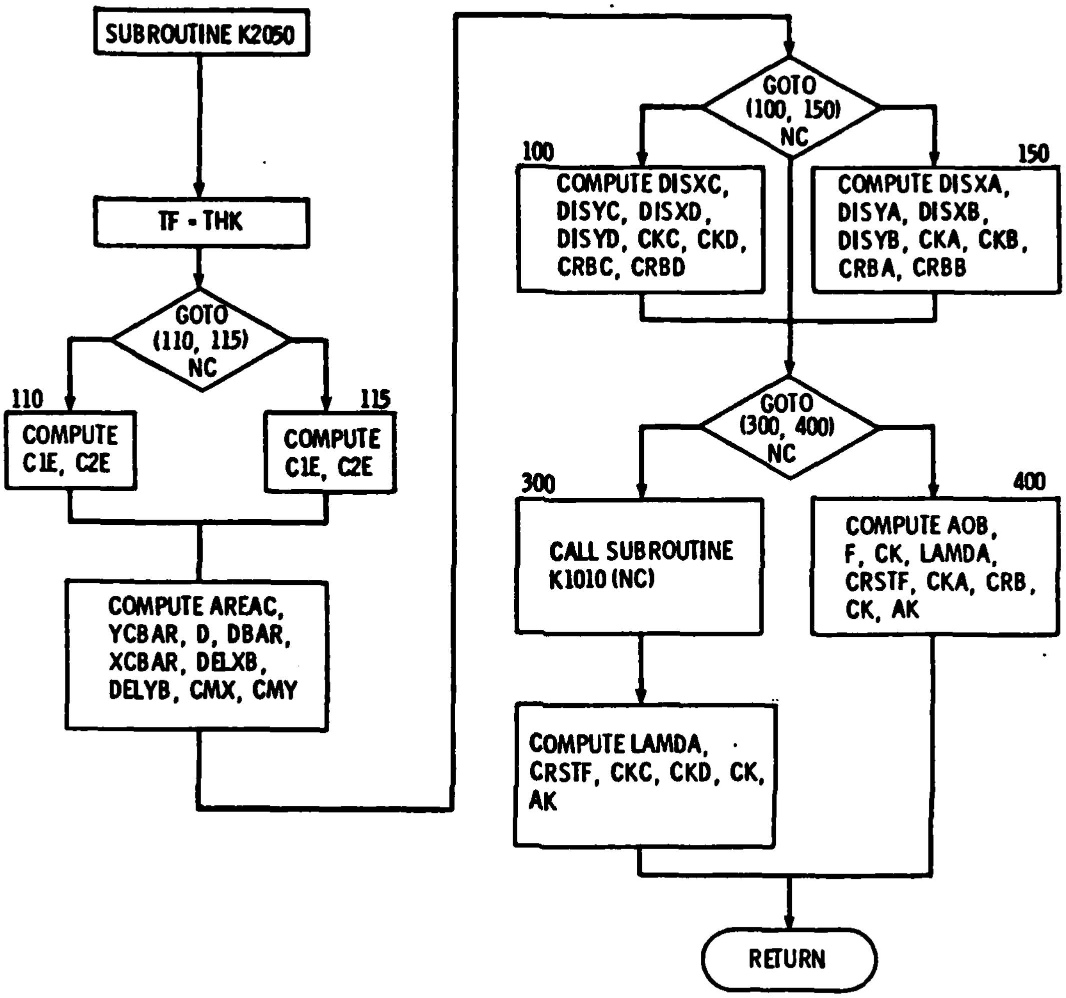


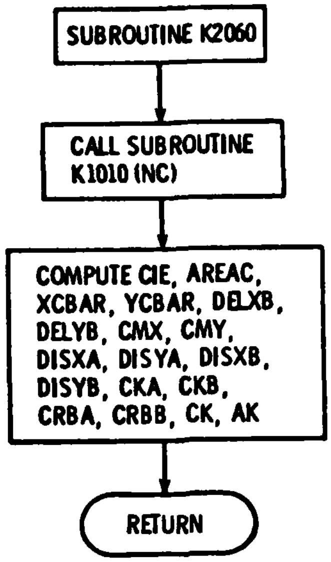
SUBROUTINE K2010
CALL SUBROUTINE K1010 (NC)
COMPUTE BETA, AA
SFJ < 1
YES
COMPUTE B
NO
COMPUTE AP
IND1 = 1000
YES
NO
COMPUTE X1, B, AA1, LAMDA, X, F1, F2, F3, Y1, IND1
C ≥ X1
YES
NO
COMPUTE B
A
A
COMPUTE LAMDA, X, F1, F2, F3, CRSF, CK, AK
RETURN
SFJ < 1.0
NO
C > AP + CLTD
YES
COMPUTE CPTHK
C > APTHK
YES
NO
IND2 = 1000
YES
NO
COMPUTE AREA, ARC, Y2, X2, SLOPE, IND2
WRITE CRACK NO. . .
IFINAL = 1
RETURN
COMPUTE CAP, AREA, CRC, CRSF
COMPUTE CRSFJ
COMPUTE CK, AK
RETURN

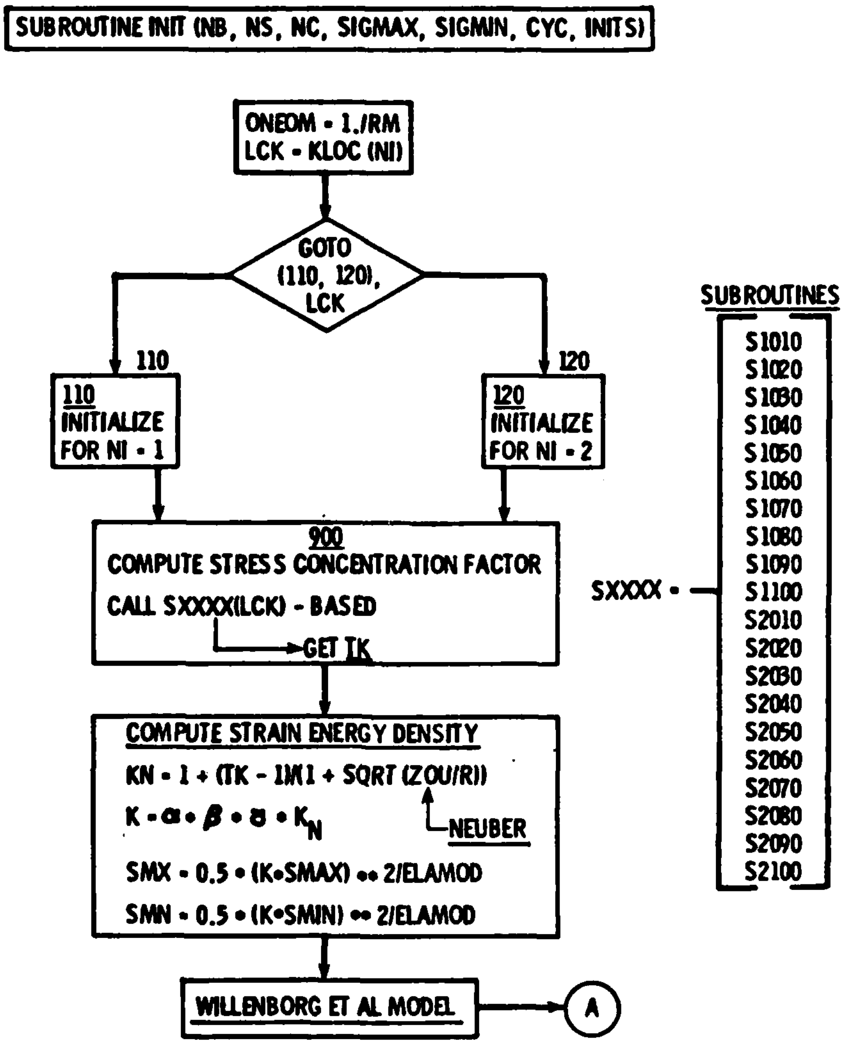

SUBROUTINE K2020
IND1 = NC
IND2 = NC
A = A1NEW
C = C1NEW
CALL SUBROUTINE K1020 (NC)
COMPUTE BETA, AA
SFJ < 1
YES
WRITE SFJ IS INCORRECT . . . .
STOP
NO
COMPUTE AP
IND1 = 1000
NO
COMPUTE X1, B, AA1, LAMDA, X, F1, F2, F3, Y1, IND1
YES
C ≥ X1
NO
COMPUTE B, LAMDA X, F1, F2, F3, CRSF, CK, AK
RETURN
YES
C > AP + CLTD
YES
WRITE CRACK NO. . . . .
IFINAL = 1
NO
COMPUTE APTHK, APTKB, APC
C > APTHK
YES
COMPUTE AREA, ARC, CRSF, CAP
NO
IND2 = 1000
NO
COMPUTE AREA, ARC, Y2, X2, SLOPE, IND2
YES
COMPUTE CRSFJ
COMPUTE CK, AK
RETURN

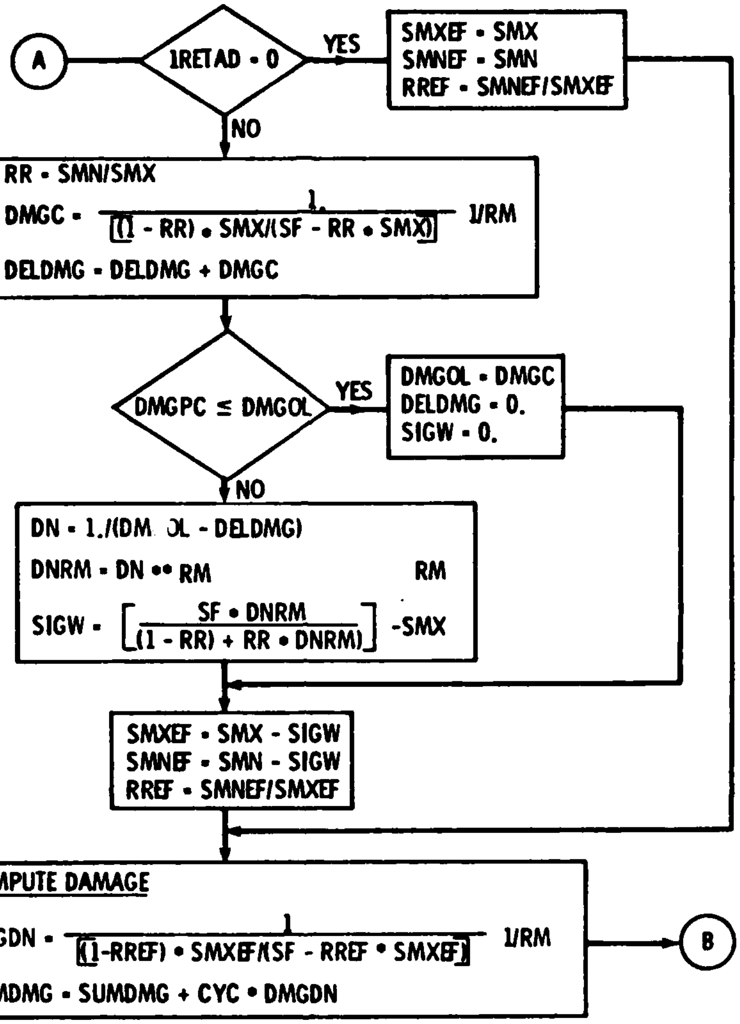

SUBROUTINE K2040
IND1 = NC
IND2 = NC
CALL SUBROUTINE K1040 (NC)
GOTO (300,350) NC
300
350
COMPUTE C1E, C2E
COMPUTE C1E, C2E
COMPUTE BETA, AA
SFJ < 1
YES
NO
WRITE SFJ
STOP
COMPUTE AP
IND1 = 1000
NO
YES
COMPUTE LAMDA, X, F1, F2, F3, Y1, X1, IND1
COMPUTE B, LAMDA
LAMDA >0.85
NO
YES
COMPUTE X, F1, F2, F3, CRSF, CK, AK
RETURN
C1E AP + CLTD
YES
NO
WRITE 'CRACK NO. ....'
IFINAL = 1
A

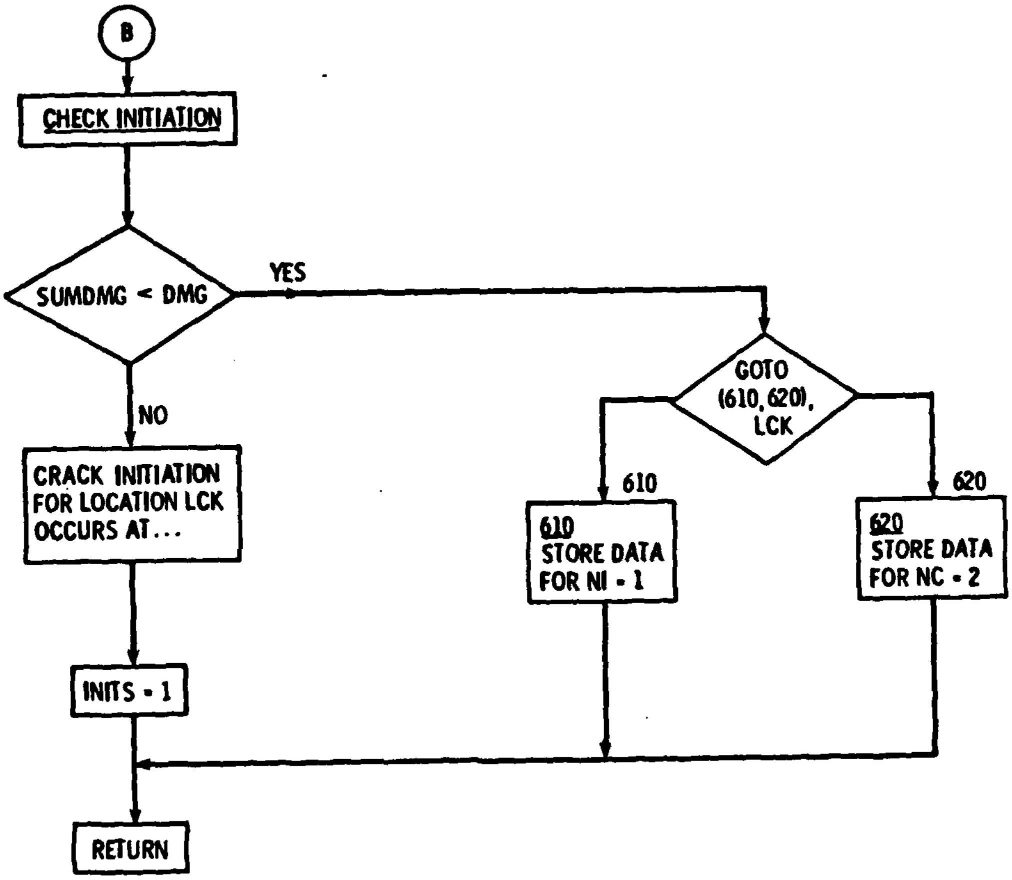

A
COMPUTE APTHK
C1E > APTHK
YES
COMPUTE CAP, AREA, ARC, CRSF
NO
IND2 = 1000
YES
NO
COMPUTE AREA, ARC, Y2, AA2, X2 SLOPE, IND2
COMPUTE CRSFJ
COMPUTE CK, AK
RETURN

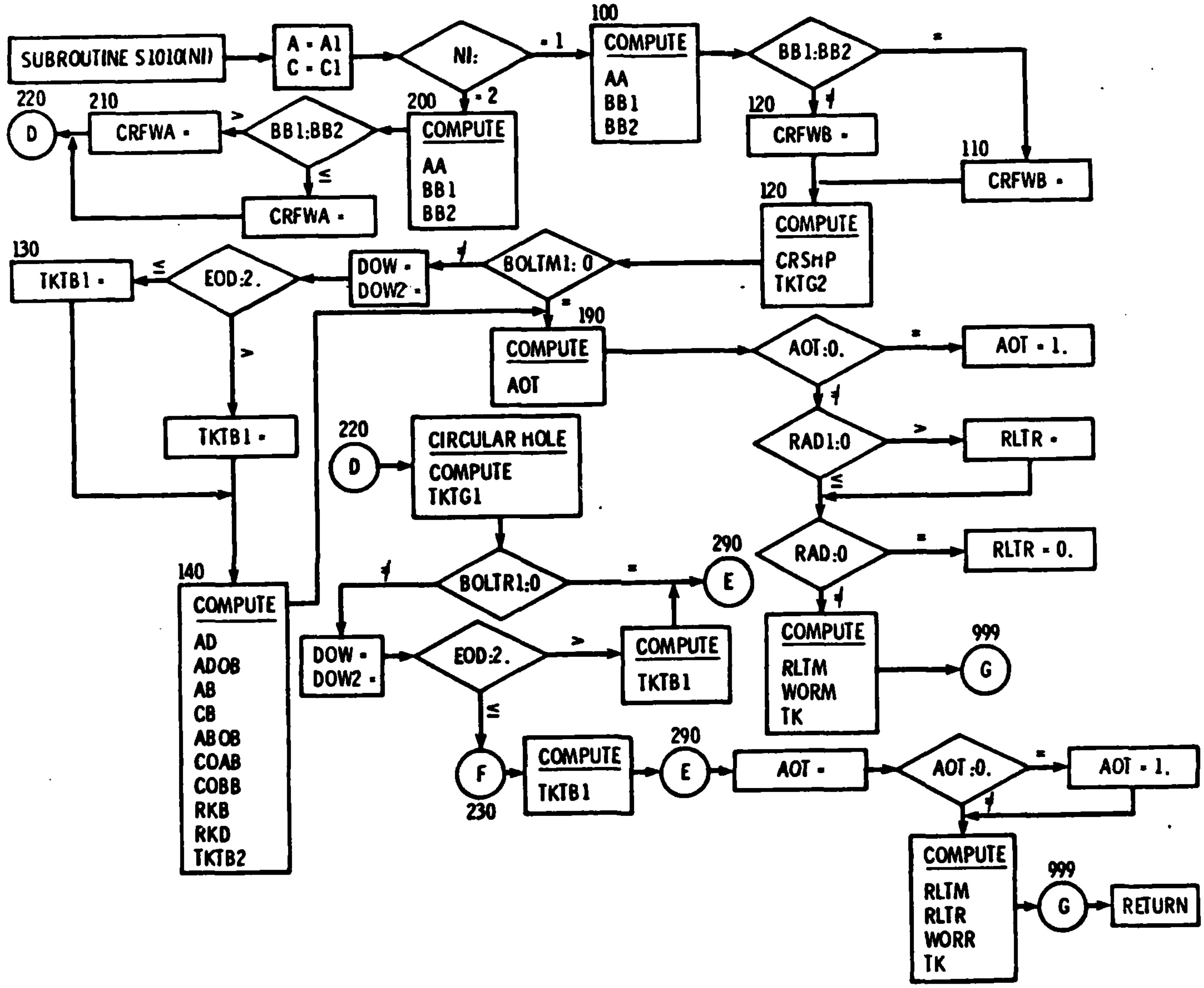

SUBROUTINE K2050
TF = THK
GOTO (110, 115) NC
110
COMPUTE C1E, C2E
115
COMPUTE C1E, C2E
COMPUTE AREAC, YCBAR, D, DBAR, XCBAR, DELXB, DELYB, CMX, CMY
GOTO (100, 150) NC
100
COMPUTE DISXC, DISYC, DISXD, DISYD, CKC, CKD, CRBC, CRBD
150
COMPUTE DISXA, DISYA, DISXB, DISYB, CKA, CKB, CRBA, CRBB
GOTO (300, 400) NC
300
CALL SUBROUTINE K1010 (NC)
400
COMPUTE AOB, F, CK, LAMDA, CRSTF, CKA, CRB, CK, AK
COMPUTE LAMDA, CRSTF, CKC, CKD, CK, AK
RETURN


SUBROUTINE K2060
CALL SUBROUTINE K1010 (NC)
COMPUTE CIE, AREAC, XCBAR, YCBAR, DELXB, DELYB, CMX, CMY, DISXA, DISYA, DISXB, DISYB, CKA, CKB, CRBA, CRBB, CK, AK
RETURN

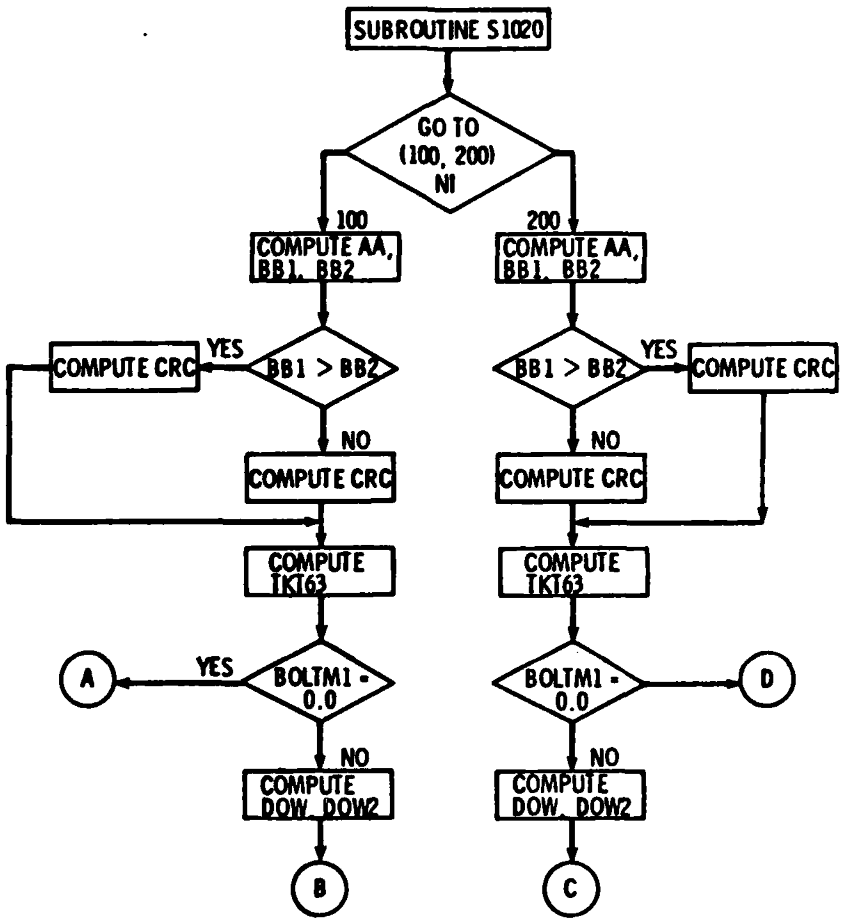

SUBROUTINE INIT (NB, NS, NC, SIGMAX, SIGMIN, CYC, INITS)
ONEOM = 1./RM
LCK = KLOC (NI)
GOTO (110, 120), LCK
110
120
110 INITIALIZE FOR NI = 1
120 INITIALIZE FOR NI = 2
900 COMPUTE STRESS CONCENTRATION FACTOR
CALL SXXXX(LCK) - BASED
GET TK
COMPUTE STRAIN ENERGY DENSITY
KN = 1 + (TK - 1)/(1 + SQRT (ZOU/R))
NEUBER
SMX = 0.5 * (K*SMAX) ** 2/ELAMOD
SMN = 0.5 * (K*SMIN) ** 2/ELAMOD
WILLENBORG ET AL MODEL
A
SUBROUTINES
SXXXX =
S1010
S1020
S1030
S1040
S1050
S1060
S1070
S1080
S1090
S1100
S2010
S2020
S2030
S2040
S2050
S2060
S2070
S2080
S2090
S2100


A
IRETAD = 0
YES
SMXEF = SMX
SMNEF = SMN
RREF = SMNEF/SMXEF
NO
RR = SMN/SMX
DMGC = 1. / [(1 - RR) • SMX/(SF - RR • SMX)] 1/RM
DELDMG = DELDMG + DMGC
DMGPC ≤ DMGOL
YES
DMGOL = DMGC
DELDMG = 0.
SIGW = 0.
NO
DN = 1./(DMGOL - DELDMG)
DNRM = DN ** RM
SIGW = [SF • DNRM / ((1 - RR) + RR • DNRM)] RM -SMX
SMXEF = SMX - SIGW
SMNEF = SMN - SIGW
RREF = SMNEF/SMXEF
COMPUTE DAMAGE
DMGDN = 1 / [(1-RREF) • SMXEF/(SF - RREF • SMXEF)] 1/RM
SUMDMG = SUMDMG + CYC • DMGDN
B

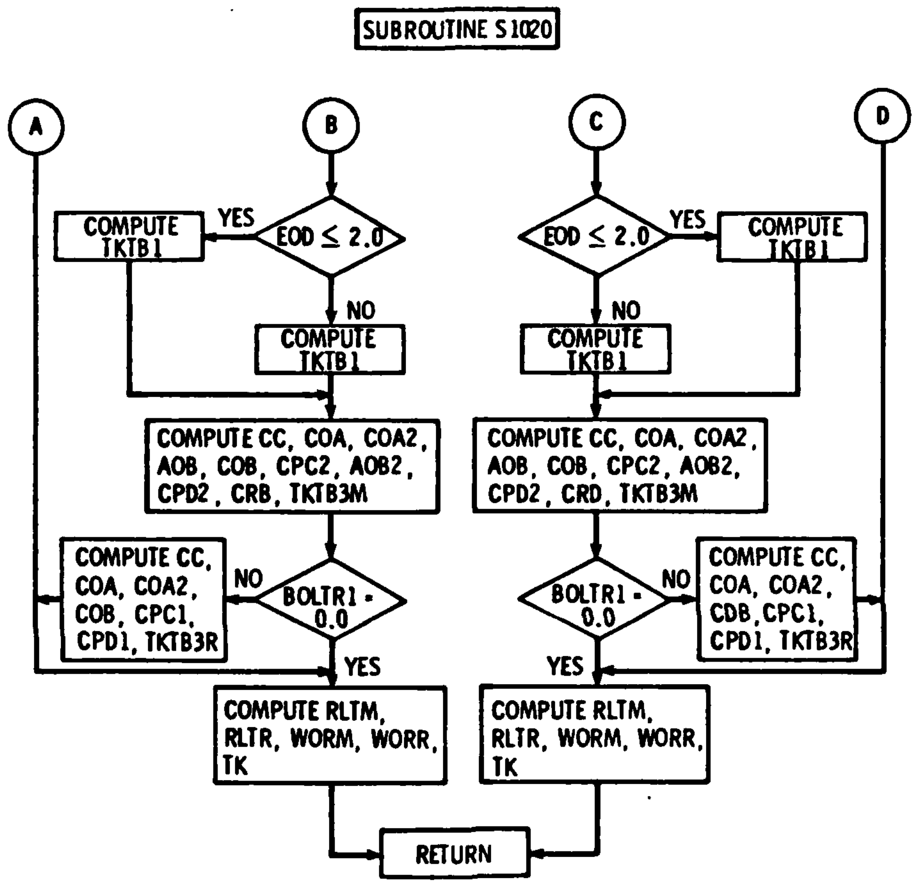

B
CHECK INITIATION
SUMDMG < DMG
YES
NO
GOTO
(610, 620),
LCK
610
620
CRACK INITIATION
FOR LOCATION LCK
OCCURS AT...
610
STORE DATA
FOR NI = 1
620
STORE DATA
FOR NC = 2
INITS = 1
RETURN

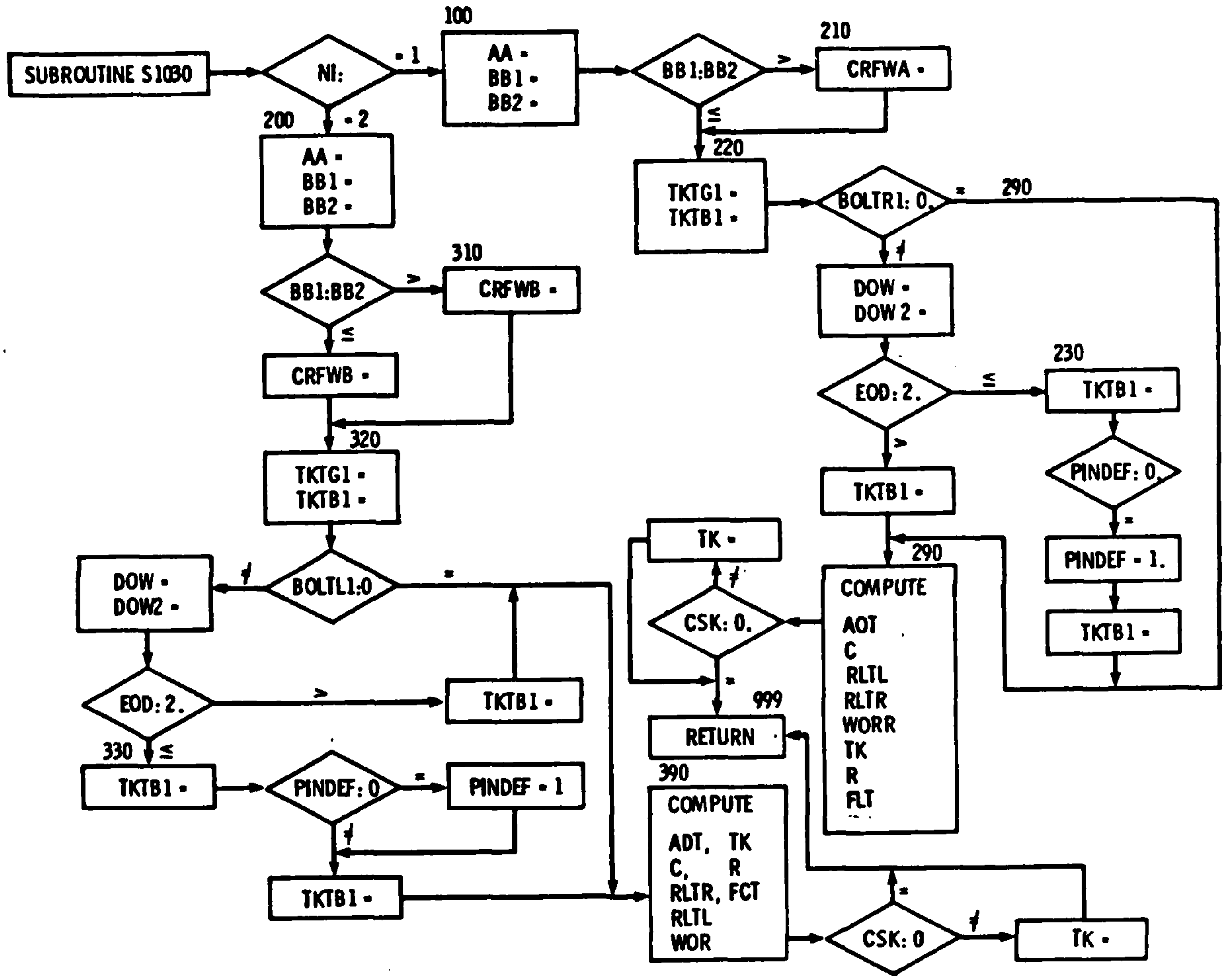


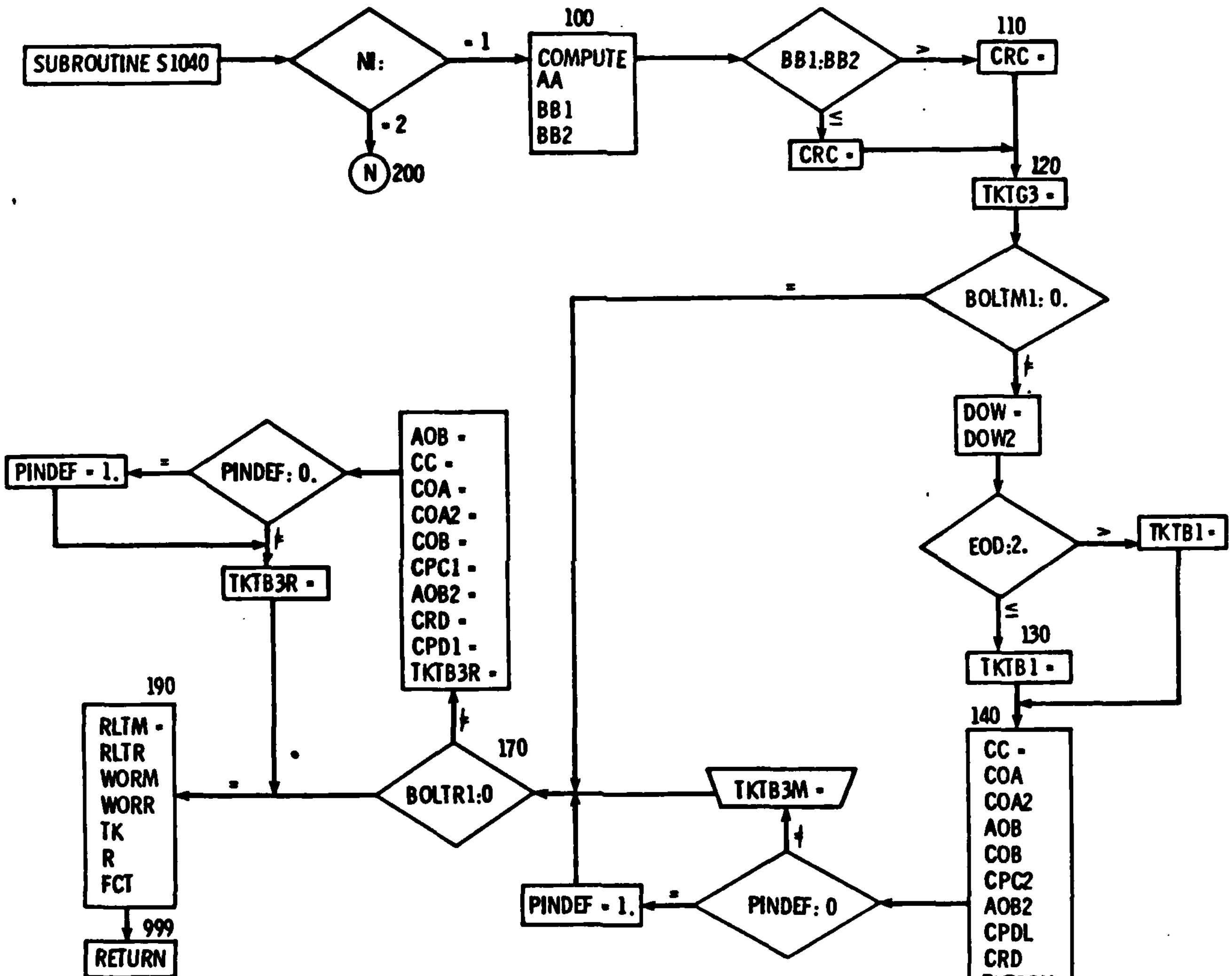
SUBROUTINE S1010(NI)
A = A1
C = C1
NI:
= 1
= 2
100
COMPUTE
AA
BB1
BB2
BB1:BB2
=
≠
120
CRFWB =
110
CRFWB =
120
COMPUTE
CRSHP
TKTG2
200
COMPUTE
AA
BB1
BB2
BB1:BB2
>
≤
210
CRFWA =
CRFWA =
220
D
BOLTM1: 0
≠
=
DOW =
DOW2 =
EOD:2.
≤
>
130
TKTB1 =
TKTB1 =
190
COMPUTE
AOT
AOT:0.
=
AOT = 1.
≠
RAD1:0
>
RLTR =
≤
RAD:0
=
RLTR = 0.
≠
COMPUTE
RLTM
WORM
TK
999
G
140
COMPUTE
AD
ADOB
AB
CB
ABOB
COAB
COBB
RKB
RKD
TKTB2
220
D
CIRCULAR HOLE
COMPUTE
TKTG1
BOLTR1:0
≠
=
290
E
DOW =
DOW2 =
EOD:2.
>
≤
COMPUTE
TKTB1
F
230
COMPUTE
TKTB1
290
E
AOT =
AOT:0.
=
AOT = 1.
≠
COMPUTE
RLTM
RLTR
WORR
TK
999
G
RETURN

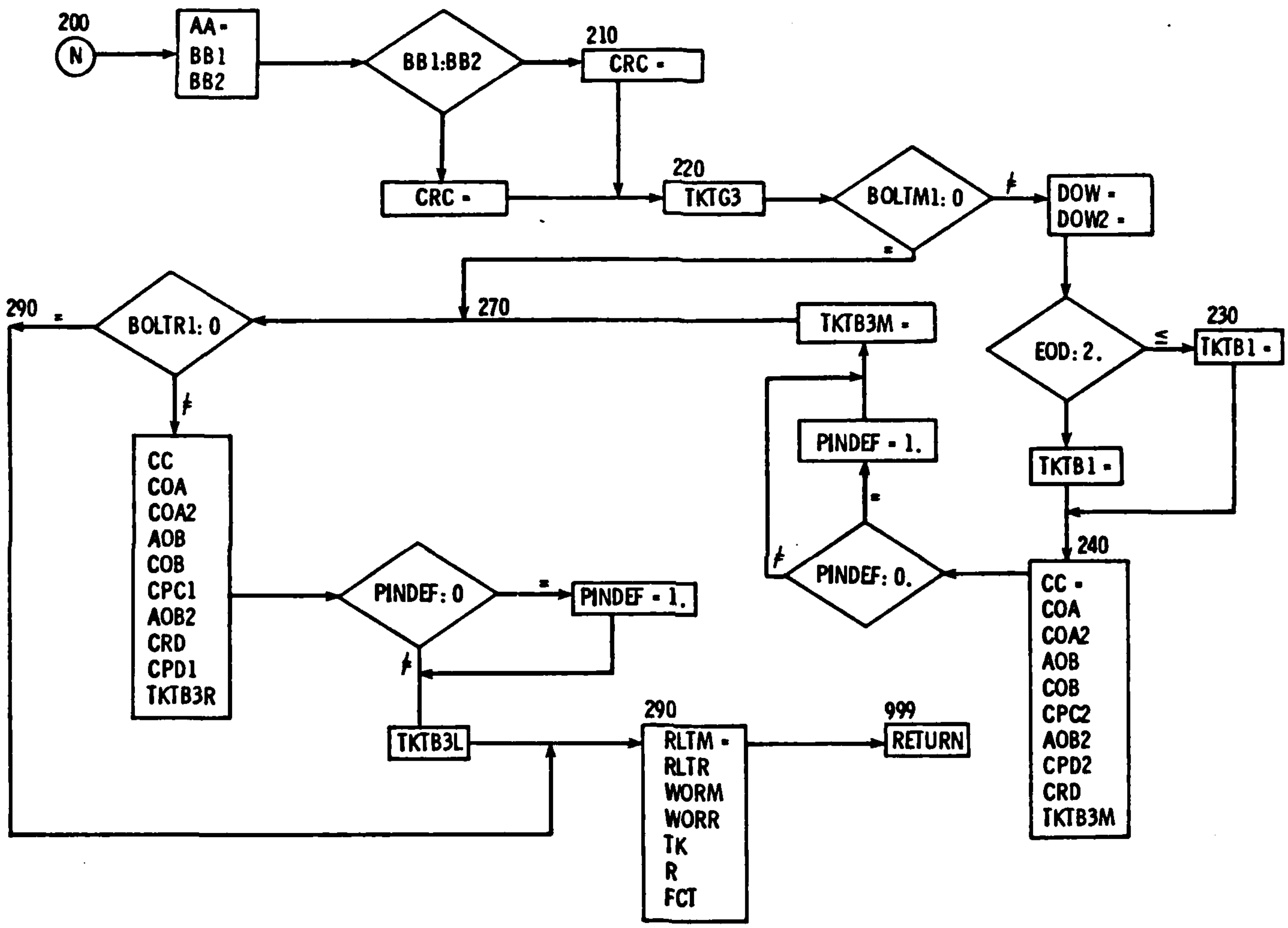


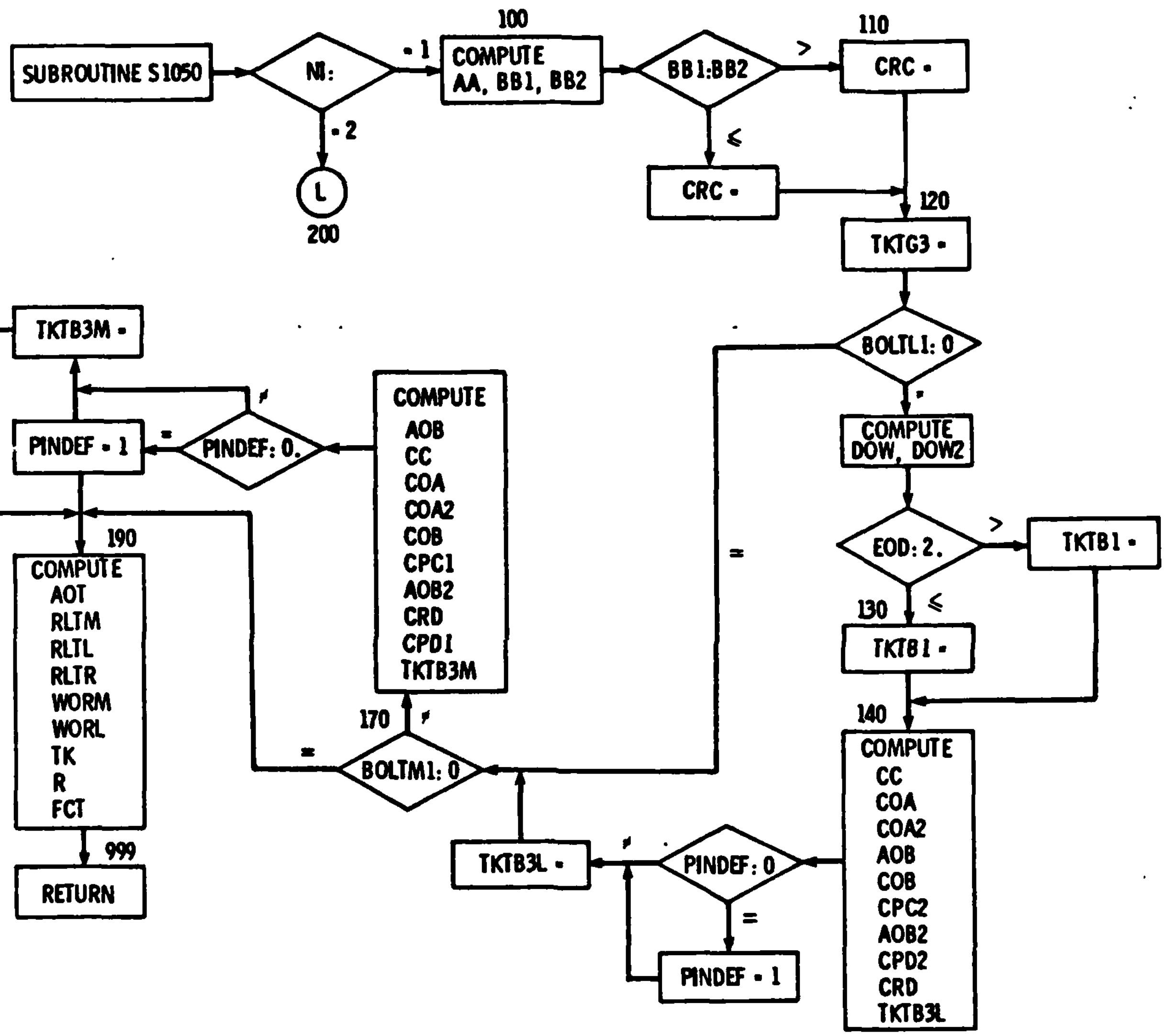
SUBROUTINE S1020
GO TO
(100, 200)
NI
100
200
COMPUTE AA,
BB1, BB2
COMPUTE AA,
BB1, BB2
COMPUTE CRC
YES
BB1 > BB2
BB1 > BB2
YES
COMPUTE CRC
NO
NO
COMPUTE CRC
COMPUTE CRC
COMPUTE
TKT63
COMPUTE
TKT63
A
YES
BOLTM1 =
0.0
BOLTM1 =
0.0
D
NO
NO
COMPUTE
DOW, DOW2
COMPUTE
DOW, DOW2
B
C

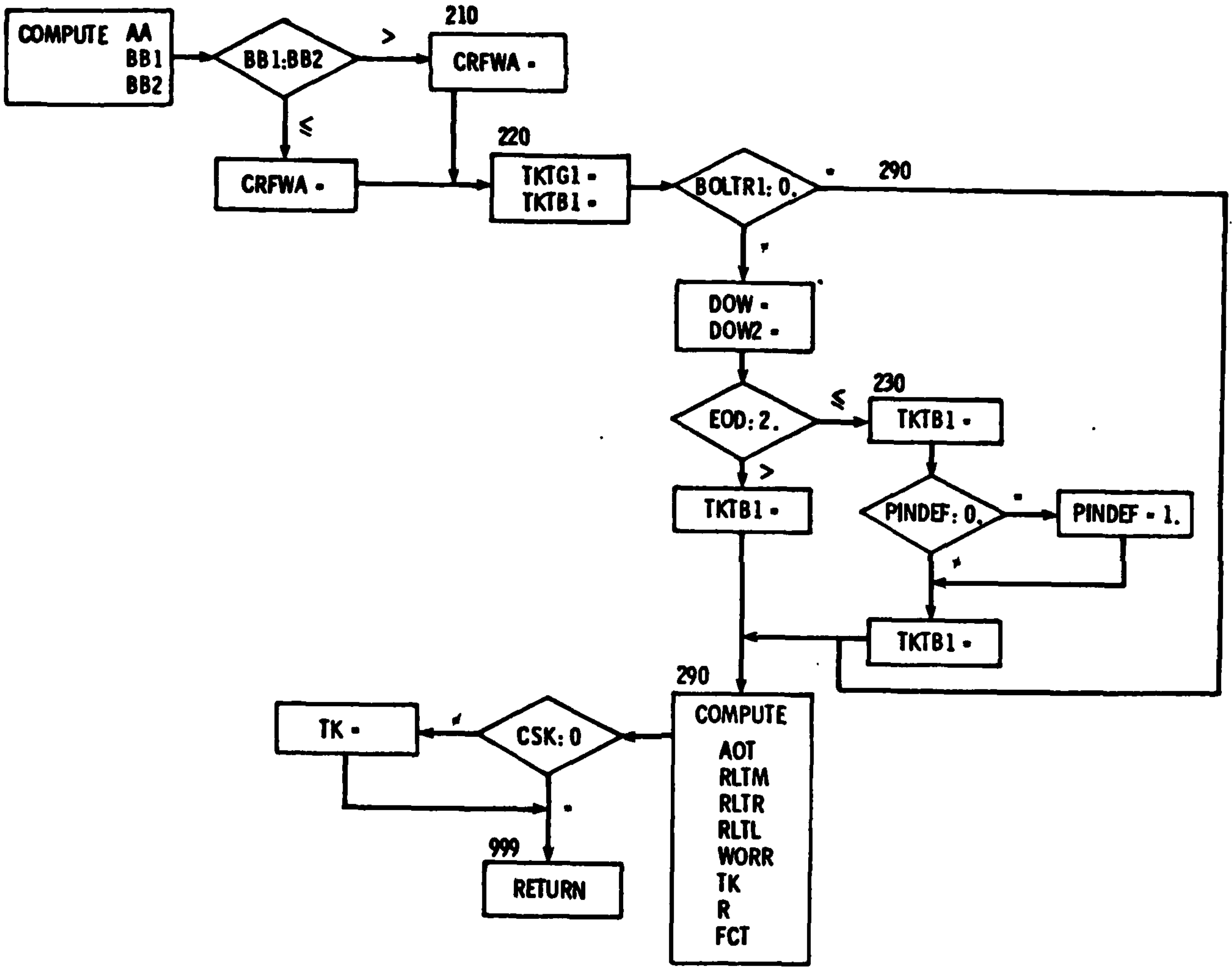

SUBROUTINE S1020
A
B
C
D
COMPUTE TKTB1
YES
EOD ≤ 2.0
EOD ≤ 2.0
YES
COMPUTE TKTB1
NO
NO
COMPUTE TKTB1
COMPUTE TKTB1
COMPUTE CC, COA, COA2, AOB, COB, CPC2, AOB2, CPD2, CRB, TKTB3M
COMPUTE CC, COA, COA2, AOB, COB, CPC2, AOB2, CPD2, CRD, TKTB3M
COMPUTE CC, COA, COA2, COB, CPC1, CPD1, TKTB3R
NO
BOLTR1 = 0.0
BOLTR1 = 0.0
NO
COMPUTE CC, COA, COA2, CDB, CPC1, CPD1, TKTB3R
YES
YES
COMPUTE RLTM, RLTR, WORM, WORR, TK
COMPUTE RLTM, RLTR, WORM, WORR, TK
RETURN

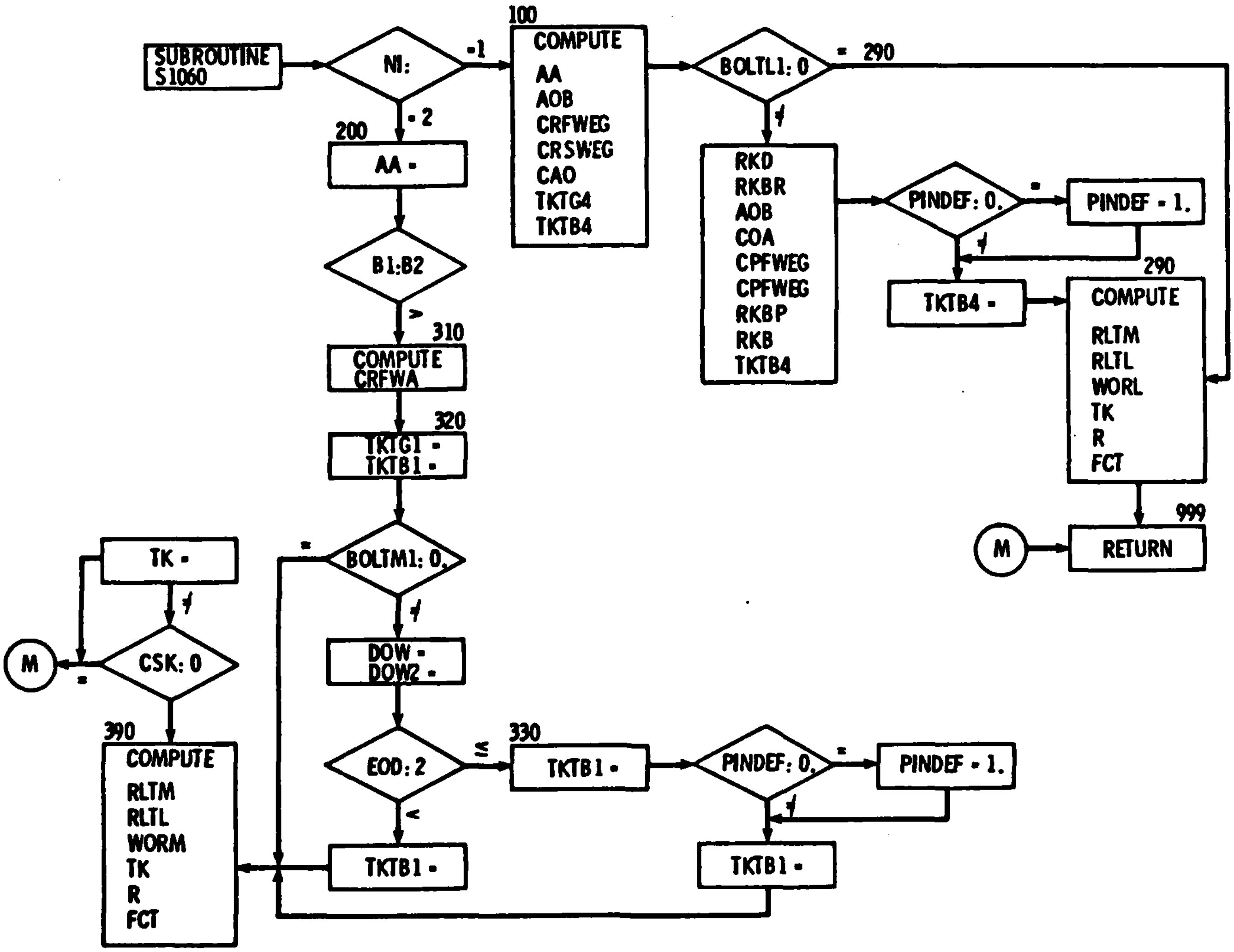

SUBROUTINE S1030
NI:
= 1
= 2
100
AA =
BB1 =
BB2 =
BB1:BB2
>
≤
210
CRFWA =
220
TKTG1 =
TKTB1 =
BOLTR1: 0.
=
≠
290
DOW =
DOW 2 =
230
EOD: 2.
≤
>
TKTB1 =
PINDEF: 0.
PINDEF = 1.
TKTB1 =
200
AA =
BB1 =
BB2 =
BB1:BB2
310
CRFWB =
CRFWB =
320
TKTG1 =
TKTB1 =
BOLTL1:0
DOW =
DOW2 =
EOD: 2.
TKTB1 =
330
TKTB1 =
PINDEF: 0
PINDEF = 1
TKTB1 =
TK =
CSK: 0.
999
RETURN
290
COMPUTE
AOT
C
RLTL
RLTR
WORR
TK
R
FLT
390
COMPUTE
ADT, TK
C, R
RLTR, FCT
RLTL
WOR
CSK: 0
TK =


SUBROUTINE S1040
NI:
= 1
= 2
N
200
100
COMPUTE
AA
BB1
BB2
BB1:BB2
>
≤
110
CRC =
CRC =
120
TKTG3 =
BOLTM1: 0.
=
≠
DOW =
DOW2
EOD:2.
>
TKTB1 =
≤
130
TKTB1 =
140
CC =
COA
COA2
AOB
COB
CPC2
AOB2
CPDL
CRD
TKTB3M
PINDEF: 0
=
PINDEF = 1.
≠
TKTB3M =
BOLTR1:0
170
≠
AOB =
CC =
COA =
COA2 =
COB =
CPC1 =
AOB2 =
CRD =
CPD1 =
TKTB3R =
PINDEF: 0.
=
PINDEF = 1.
≠
TKTB3R =
=
190
RLTM =
RLTR
WORM
WORR
TK
R
FCT
999
RETURN


200
N
AA =
BB1
BB2
BB1:BB2
210
CRC =
CRC =
220
TKTG3
BOLTM1: 0
≠
=
DOW =
DOW2 =
290
=
BOLTR1: 0
270
TKTB3M =
EOD: 2.
≤
230
TKTB1 =
≠
PINDEF = 1.
TKTB1 =
=
240
CC
COA
COA2
AOB
COB
CPC1
AOB2
CRD
CPD1
TKTB3R
≠
PINDEF: 0.
CC =
COA
COA2
AOB
COB
CPC2
AOB2
CPD2
CRD
TKTB3M
PINDEF: 0
=
PINDEF = 1.
≠
TKTB3L
290
RLTM =
RLTR
WORM
WORR
TK
R
FCT
999
RETURN


SUBROUTINE S1050
NI:
= 1
= 2
L
200
100
COMPUTE AA, BB1, BB2
BB1:BB2
>
≤
110
CRC =
CRC =
120
TKTG3 =
BOLTL1: 0
≠
=
COMPUTE DOW, DOW2
EOD: 2.
>
≤
TKTB1 =
130
TKTB1 =
140
COMPUTE
CC
COA
COA2
AOB
COB
CPC2
AOB2
CPD2
CRD
TKTB3L
PINDEF: 0
≠
=
PINDEF = 1
TKTB3L =
170
BOLTM1: 0
≠
=
COMPUTE
AOB
CC
COA
COA2
COB
CPC1
AOB2
CRD
CPD1
TKTB3M
PINDEF: 0.
≠
=
PINDEF = 1
TKTB3M =
190
COMPUTE
AOT
RLTM
RLTL
RLTR
WORM
WORL
TK
R
FCT
999
RETURN


COMPUTE AA BB1 BB2
BB1:BB2
>
≤
210
CRFWA =
CRFWA =
220
TKTG1 =
TKTB1 =
BOLTR1: 0.
=
290
≠
DOW =
DOW2 =
EOD: 2.
≤
230
TKTB1 =
>
TKTB1 =
PINDEF: 0.
=
PINDEF = 1.
≠
TKTB1 =
290
COMPUTE
AOT
RLTM
RLTR
RLTL
WORR
TK
R
FCT
CSK: 0
≠
TK =
=
999
RETURN



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